COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM SEARCH SUBSIDY ACTS

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O.D.N.L. PENOLA No. 1 WELL, SOUTH AUSTRALIA

OF

OIL DEVELOPMENT N.L.

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1963

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

Minister: SENATOR THE HON. SIR WILLIAM SPOONER, K.C.M.G., M.M.

Secretary: H. G. 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.

The drilling of Penola No. 1 was carried out under the Petroleum Search Subsidy Act 1959 in the Penola area of South Australia (north-east corner of Section 500, Lat. 37° 20' 38" S., Long. 140° 52' 35" E.) by Oil Development N.L. This Publication deals with the results of this drilling operation and contains information furnished by Oil Development N.L. and edited in the Petroleum Exploration Branch of the Bureau of Mineral Resources. The final report was prepared by R. Hare and Associates who acknowledge the contributors of information incorporated in the report. The methods employed in the drilling operation and the results obtained are presented in detail.

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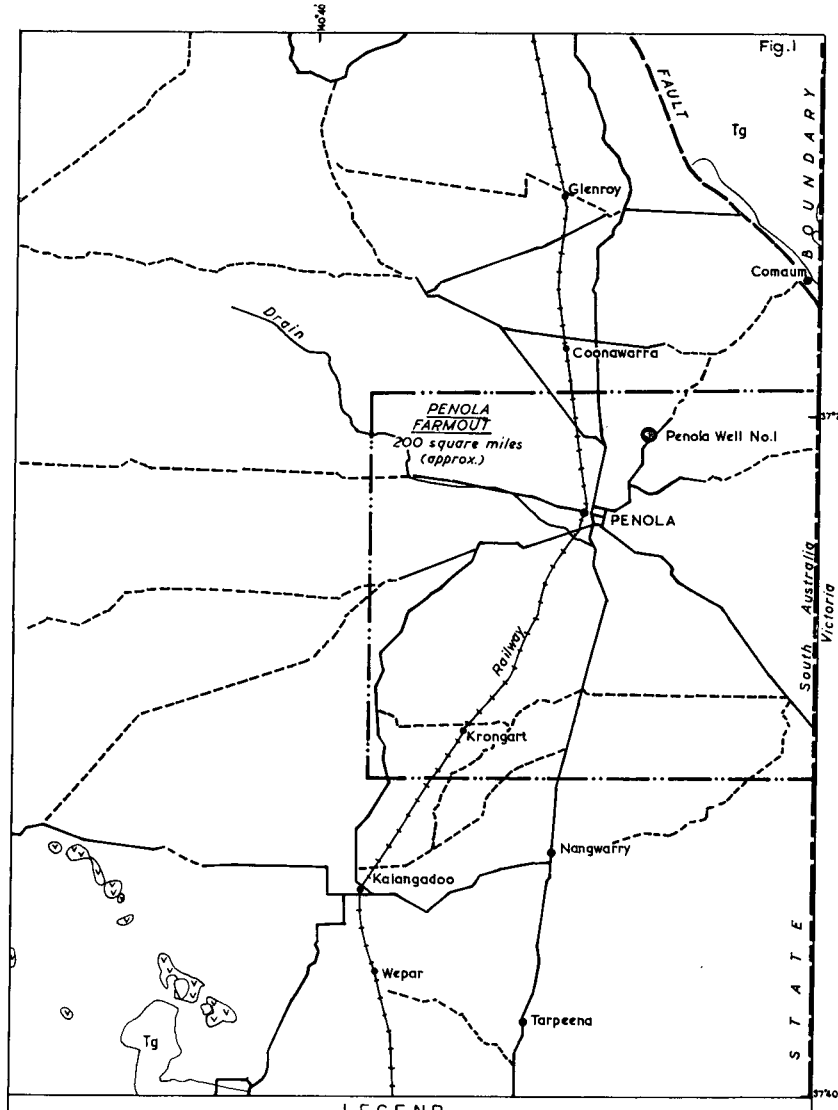


OIL DEVELOPMENT N. L.

OIL EXPLORATION LICENCE No 22, SOUTH AUSTRALIA

LOCALITY MAP OF O.D.N.L. PENOLA WELL No. ONE

Note: GEOLOGY FROM "PENOLA 4 MILE GEOLOGICAL MAP" (SOUTH AUST. MINES DEPT., 1951.)

0 4 8 12 MILES

SUMMARY

O.D.N.L. Penola No. 1 Well, located in the north-east corner of Section 500, Hundred of Penola, South Australia, was drilled by Oil Development N.L. under a "farm-out" agreement with General Exploration Company of Australia Limited to a total depth of 4985 feet. Drilling was commenced on 7th February, 1961, and the well was abondoned as a dry hole on 5th May, 1961. The drilling contractor was Australian Tube Wells Pty Ltd, and the rig used was a Failing 2500 - Holemaster. The operation provided for a programme of electric and mud logging, testing and coring.

The Penola Well was designed to test the petroleum potentialities of the Coonawarra subsurface structure, which was first detected by a single reconnaissance seismic reflection traverse made through the Penola area. Beneath a thin Pleistocene cover Penola No. 1 penetrated a sequence of marine and paralic Tertiary, and marine and non-marine Mesozoic rocks, ranging in age from Oligocene to probable Upper Jurassic. The Tertiary sediments consisted of 215 feet of Gambier Limestone (Oligocene); 160 feet of Compton Conglomerate (Oligocene); followed by about 630 feet of paralic sands and grits of the Knight Group (middle to upper Eocene).

There is a marked discontinuity at 1040 feet where the well passed abruptly from the Eocene to Cretaceous arkosic sandstones and siltstones of the Merino Group. The Upper Member of the Runnymede Formation of Albian to (?) Cenomanian age was 2380 feet thick, and of marine origin in at least the lower 800 feet, between 2586 and 3420 feet. The lower non-marine member of the Runnymede Formation (? Aptian) was represented between 3420 and 4300 feet. A slight angular unconformity is interpreted at about 4300 feet, below which the well is considered to have entered non-marine mudstones and sandstones of the Mocamboro Member of probable Upper Jurassic age.

Minor showings of gas were encountered at Penola No. 1, none being of commerial significance. No signs of live oil were observed in the well.

INTRODUCTION

The Penola No. 1 Well was designed to determine the subsurface stratigraphy and to test the potentialities of a suspected sequence of Cretaceous sediments in the Coonawarra structure, the extent of which had previously been delineated by detailed seismic survey. The site selected for the well was on the south-west flank of the structure, at a short distance from the peak of the culmination.

The rig was moved by road from Adelaide and assembled as it arrived on site. The well was spudded in at 1.50 p.m., 7th February, 1961.

A 12 1/4" hole was drilled to 503 feet. Lost circulation was encountered at 37 feet and continued to 503 feet, over which interval only intermittent returns were obtained. A string of 9 5/8" J.55, 36lb casing was run to 497 feet and cemented to surface. An 8 1/2" hole was then drilled to 2501 feet with no further loss of circulation. Electric and Microlog-Caliper logs were run between 496 and 2487 feet, and an intermediate string of 7" J.55, 20lb casing was then set at 2488 feet and cemented to surface. A 5 5/8" hole was drilled ahead to a total depth of 4985 feet at which point the drill pipe became stuck in the hole. Efforts to free the pipe failed and the tools were backed off at 4200 feet using a string shot. An electric log was then run from 2487 to 4159 feet and a Microlog-Caliper survey between 2487 and 3372 feet.

Pleistocene, Oligocene, Eocene, Cretaceous and probable Jurassic sediments were penetrated. In the zone of lost circulation between 320 and 503 feet it is presumed that a small portion in the upper part of this section may be referred to the equivalent of the Oligocene Compton Conglomerate and the remainder to the Eocene Knight Group; in both cases, the sediments in this interval were probably loose, coarse to fine sands, with possibly some gravels in the upper part.

Twenty-one cores were cut using a 20-foot Reed K 500 "Kor-King" barrel. Samples were collected at 5-foot intervals throughout the entire section penetrated except over the lost circulation intervals.

A "Wemco" gas detector with a hydrogen flame ionizing cell operated from 4280 to 4785 feet and from 4930 to 4985 feet. This instrument detected intermittent rises in the hydrocarbon content of the drilling mud.

Very slight bubbling of gas from low porosity sandstone was observed in a core taken at 4600 feet. A drill stem test was attempted over this interval but satisfactory packer seat could not be obtained, and the low porosity did not warrant persevering with this zone any further.

The Electric logs indicated that a 3-foot sand at 3980 feet possibly contained hydrocarbons. However, a drill stem test covering the interval recovered only 16 feet of drilling fluid.

A gas-air sample collected while circulating at 4000 feet was analysed and found to contain a small amount of hydrocarbon gas consisting of 98.9% methane with 1.1% of higher hydrocarbons, which indicates a probable coal seam source for this gas. (See Appendix 5).

Deviation surveys were carried out at 500-foot intervals from 1000 to 4500 feet. Maximum deviation from vertical was 1 1/2° at 2000 feet and at 4500 feet.

The well was abandoned by setting cement plugs from 4175 to 4211 feet, 3962 to 4008 feet, 2901 to 2934 feet, 2455 to 2507 feet, and from surface to 80 feet. A steel plate was then welded across the top of the casing.

WELL HISTORY

General Data

Well name and number:	O.D.N.L. Penola No. 1
Location:	South Australia, Hundred of Penola, North-east corner of Section 500. Lat. 37° 20' 38" S., Long. 140° 52' 35" E.
Tenement Holder:	General Exploration Company of Australia Limited.
Details of Petroleum Tenement:	Oil Exploration Licence No. 22. The location of Penola No. 1 Well lies within Oil Exploration Licence No. 22/1, South Australia, the title to which is held by General Exploration Company of Australia Limited. The area of this Licence is 4900 square miles and the date of expiry is 30.4.1964. Under a "farm-out" arrangement with General Exploration Co. of Australia Ltd, dated 30.8.1960, Oil Development N.L. selected an Exploratory Area of 200 square miles surrounding the town of Penola and falling entirely within the area of O.E.L. 22/1. Under the terms of this agreement Oil Development N.L. earned a 50 percent interest in the Exploratory Area by the drilling of Penola No. 1 Well.
District:	Penola, South Australia
Total depth:	4985 feet
Date drilling commenced:	7th February, 1961
Date drilling completed:	18th April, 1961
Date well abandoned:	5th May, 1961
Date rig released:	5th May, 1961
Drilling time in days to total depth:	71
Elevation:	Rotary Table 209.2 feet Ground: 204.2 feet (Elevations are given above Low Water Mark in Port Adelaide)
Status:	Abandoned

Drilling Data

Drilling Contractor:	Australian Tube Wells Pty Ltd, 175 North Terrace, Adelaide, South Australia		
Drilling Plant:			
Make:	Failing		
Type:	2500 - Holemaster		
Rated capacity with 3 1/2" pipe:	2500 feet		
Rated capacity with 2 3/8" pipe:	5000 feet		
Motors:	Two Hercules DWXE Diesel 105 h.p.		
Mast:			
Make:	Failing		
Type:	Seamless Alloy Steel tubing with 4-way taper		
Rated capacity:	60,000 lb.		
Pumps:	(1)	(2)	(3)
Make:	Oilwell 214P	Wheatley	Mindrill
Type:	Duplex	Duplex	Duplex
Size:	7 1/4" x 14"	5" x 10"	4 1/2" x 5"
Motors:	GM Series 71 300 h.p.	Rig Motor	Perkins L4 49 h.p.
Blowout Preventer equipment:			
Make:	Schaeffer double gate		
Size:	10 3/4"		
Series:	A.P.I. 900		
Hole sizes and depths:	12 1/4" to 503 feet 8 1/2" to 2501 feet 5 5/8" to 4985 feet		
Casing details:			
Size:	9 5/8"	7"	
Weight:	36 lb/ft.	20 lb/ft.	
Grade:	J.55	J.55	
Range:	2	2	
Setting depth:	497 feet	2488 feet	

Casing cementing details:

Size:	9 5/8"	7"
Setting depth:	497 feet	2488 feet
Sacks cement used:	198	325
Rise of cement behind casing:	to surface	to surface
Method used:	Plug	Plug

Drilling fluid: A light spudding mud of bentonite and water was used at the commencement of drilling. Circulation was lost at 37 feet. The well was drilled ahead using water and the following lost circulation materials: sawdust, chaff, bran, Cellofas B and paper. Cement and bentonite were also used but only intermittent returns were obtained.

After cementing the 9 5/8" casing to 497 feet a new mud was used with the following average properties:

Weight	10.15 lb/U.S. gallon
Viscosity (Marsh)	51 sec.
Filtrate	11 cc.
Cake	2/32"
pH	8
Sand	2%
Chloride	900 ppm.

The formation being drilled continually made mud, and treatment consisted of adding Myrtan and caustic soda to reduce viscosity, and sodium carboxymethyl-cellulose (C.M.C.) to reduce water loss. In addition, portions of the old mud were discarded periodically and replaced with new mud containing barytes to bring the weight to 10.15 lb/U.S. gallon, and bentonite to bring the viscosity to 35 seconds. After setting the 7" casing to 2488 feet and drilling out the cement left in it, the cement and mud were discarded and a new mud was mixed prior to drilling ahead.

This mud had the following average properties for the remainder of drilling:

Weight	10.4 lb/U.S. gallon
Viscosity (Marsh)	54 sec.
Filtrate	10 cc.
Cake	2/32"
pH	10
Sand	1%
Chloride	1100 ppm.

Variations in these mud properties were effected prior to drill stem testing and coring. Treatment, as previously, was necessary to maintain these properties, except that Calgon was used in place of Myrtan as a thinner in the final days of drilling.

The following mud materials were used in the drilling of the well:

Bentonite	495 sacks
Barytes	1346 "
C.M.C.	19 "
Myrtan	45 "
Cellofas	10 "
Calgon	80 lb.
Caustic Soda	1463 lb.

Water Supply: The water supply was obtained from a bore drilled near the well site which encountered water at 32 feet. The level of water remained constant when pumping at 6000 gallons per hour.

Perforating and Shooting Record: Nil

Plugging back and squeeze cementation jobs: The only plugs set were those for the abandonment programme and one other to provide a base for the tail pipe of the testing tool at 4175 feet. Details of the plugs are as follows:

Interval (feet)	Length (feet)	Cement (sacks)
0- 80	80	10
2455-2507	52	7
2901-2934	33	5
3962-4008	46	7
4175-4211	36	2 drums Fondu

Fishing Operations: The following fishing operations were carried out:

Depth of Hole (feet)	Fish	Equipment left in Hole
43	Half master bushing from rotary table	Nil
3514	9 1/2 stands of D.P. and 6 drill collars	Nil
4985	15 stands of D.P. and 8 drill collars	15 stands of D.P. and 8 drill collars.

Efforts were made to free the pipe stuck at 4985 feet by circulating and pulling the drill string to stretch limit, but this proved unsuccessful. String shot equipment was then called in to back off the string at the lowest possible point. Attempts were made unsuccessfully at 4915 feet and 4815 feet to back off the string. After these two attempts, it was found that the string shot could not run below 4200 feet inside the drill pipe, and the string was eventually backed off at this depth.

Side Tracked Hole: Nil

Logging and Testing

Cuttings:

Samples were collected at 5-foot intervals except above 500 feet, where only intermittent returns were obtained due to lost circulation. Four sets of samples from each 5-foot interval were obtained; these were distributed to the Bureau of Mineral Resources, the South Australian Mines Department, General Exploration Co. of Australia Ltd and Oil Development N.L. The quality of the samples generally improved with depth, but the mudstones and clays of the upper section, particularly above 1650 feet, tended to go into suspension in the drilling mud, or to disintegrate on washing. Examination of cuttings as they were collected over the shaker was maintained on a 24-hour basis.

Coring:

The original programme called for one core every 200 feet commencing at 1200 feet. This programme was maintained and at times exceeded, where bit life was less than 200 feet or when variations in lithology warranted a core being cut. A total of 21 cores were cut, using a 20-foot Reed K 500 "Kor-King" barrel. Representative portions of all cores cut were distributed on the same basis as the cuttings. Descriptions of the cores are given in detail in Appendix 1.

Side wall sampling: Nil

Electric and other logs:

The hole was logged by Schlumberger Seaco Inc. as follows:

496 to 2487 feet	Electric Log giving the S.P., 16" normal, amplified 16" normal, 64" normal and 18'8" lateral curves.
	Microlog giving the micro-inverse 1" x 1" curve and micro-normal 2" curve.
	Caliper Log.
2487 to 4159 feet	Electric Log giving the S.P., 16" normal, amplified 16" normal, 64" normal and 18'8" lateral curves.
2487 to 3372 feet	Microlog giving the micro-inverse 1" x 1" curve and micro-normal 2" curve.
	Caliper Log.

Drilling time and gas log:

The drilling time log was maintained throughout the well. The Wemco hydrogen flame ionizing cell gas indicator was operated from 4280 to 4785 feet and from 4930 to 4985 feet.

Formation testing:

The following drill stem tests were carried out:

Test No.	Interval Tested (feet)	Method	Results
1	3156 - 3190	Johnston Formation Tester	Misrun - Packer Failed
2	3179 - 3190	"	"
3	4581 - 4619	"	"
4	3968 - 4175	"	"
5	3959 - 4175	"	Rec. 16 feet drilling mud

Details of these tests are shown in Appendix 7.

Deviation surveys:

The following deviation surveys were run:

Depth (feet)	Deviation from Vertical
1004	1°
1500	0°
2000	1 1/2°
2500	3/4°
3000	1 1/4°
3500	1/2°
4000	1°
4500	1 1/2°

Temperature surveys:

Three bottom hole temperature readings were taken by Schlumberger Seaco Inc. in the course of the electric logging operations.

Depth (feet)	Temperature
2484	104°F
3372	124°F
4159	146°F

These figures indicate rather high geothermal gradients of 2.25°F per 100 feet between 2484 and 3372 feet, and of 2.78°F per 100 feet between 3372 and 4159 feet.

Other surveys:

A velocity survey was run on the well by a seismic unit of the South Australian Mines Department. (See Appendix 9).

GEOLOGY

Previous Work:

The Penola "farm-out" area of Oil Development N.L. lies within the Gambier Sunklands, which are considered by the South Australian Mines Department to form part of the Murray Basin Province. Other authorities consider the Gambier Sunklands as forming a western extension of the Otway Basin of south-western Victoria. The Gambier Sunklands have been under active geologic investigation for at least 100 years and a considerable knowledge of the surface and shallow subsurface geology has accumulated over the years.

More recently, gravity and aeromagnetic surveys of the Gambier Sunklands and adjoining areas have added to the conception of the regional structure of the area, and seismic reconnaissance has contributed to the knowledge of the deeper subsurface structure in parts of the area. The structural features of the region have recently been described in Bulletin No. 35 of the Geological Survey of South Australia (1960, p. 17, et seq.) to which reference should be made. Seismic reconnaissance showed that the sedimentary sequence becomes thicker southward from the Lucindale fault and that a substantial thickness of Cretaceous sediments could be expected in the Penola area overlying what could be interpreted as an unconformable contact with the Jurassic rocks exposed farther east on the upthrown side of the Lucindale (Kanawinka) fault.

The Penola No. 1 Well was designed to test the petroleum potentialities of the Coonawarra subsurface structure, which was first detected by a single reconnaissance seismic reflection traverse made through the Penola area for General Exploration Co. of Australia Ltd in mid-1960. Additional traverses were undertaken in December, 1960 and January, 1961, by Oil Development N.L. to determine the lateral extent and the amount of closure in what were considered to be Cretaceous sediments draped over a buried topographic "high" of a pre-Cretaceous erosion surface. It was considered that a substantial thickness of Cretaceous sediments would be found between the overlying Tertiary sediments and the Jurassic Mocamboro Member which was believed to underlie the Cretaceous sequence unconformably at a depth of about 4200 feet. The detailed seismic survey undertaken by Oil Development N.L. indicated a minimum closure of about 220 feet in the presumed Cretaceous sequence on a structure about 2.3 miles long and one mile wide. The site for the well was then selected on the south-west flank of the structure at a short distance from the peak of the culmination.

The South Australian Department of Mines has collected and examined samples from water bores and outcropping formations, and this work, together with micropalaeontological examination, has resulted in the stratigraphy of the basin becoming fairly well established. However, these investigations have been generally limited to formations of Tertiary and later ages, as very few bores have penetrated the Tertiary. These bores did little more than to establish the presence of Cretaceous rocks beneath the Tertiary. However, the drilling of the Nelson Bore revealed nearly 3000 feet of dominantly marine Cretaceous sediments.

Shallow wells drilled by the Mines Department of Victoria across the Kanawinka fault about 11 miles east of Penola No. 1 indicated a maximum thickness of 340 feet of

Eocene Knight sands in that area. Wells drilled in the vicinity of Mount Gambier penetrated nearly 2000 feet of Knight sands and clays without reaching their base. In the Nelson Bore, on the downthrow side and about 15 miles west of the trend of Kanawinka fault, nearly 3000 feet of dominantly marine Cretaceous sediments were penetrated, and this sequence, presumed to underlie the Knight sands in the Penola area, was the main prospect in the Penola No. 1 Well. The top of the Jurassic was anticipated at a depth of 4200 feet, in the prognosis for the Penola Well and was, in fact, probably encountered close to that depth.

Geophysical work in the area has been undertaken at various times and aeromagnetic surveys have completely covered the Murray Basin province south of the River Murray in South Australia. A similar condition applies with a gravity survey although this does not yet give a complete coverage. It is complete in South Australia over an area south of a line from Kingston to Bordertown.

Various seismic surveys have been carried out and in particular a seismic survey was carried out in the Penola area during 1960 and 1961. A closed structure with an areal extent of several square miles was indicated.

Stratigraphy:

Above 503 feet only intermittent mud returns were obtained and the thickness of units within that interval are only approximate. The stratigraphic sequence penetrated is:

Age	Formation	Lithology	Depth (feet)	Thickness (feet)
Pleistocene		Calcareous sandstone	0- 35	35
Oligocene	Gambier Limstone	Bryozoal limestone	35- 250	215
Oligocene	Compton Conglomerate equivalent	Sand	250- 410	160
Eocene	Knight Group	Sand	410-1040	630
Lower Cretaceous	Runnymede Formation Upper Member	Carbonaceous mudstone, siltstone and sandstone	1040-3420	2380
Lower Cretaceous	Runnymede Formation Lower Member	Coal measures. Carbonaceous mudstone, siltstone and sandstone. Grits at base	3420-4300	880
Jurassic	Mocamboro Member	Carbonaceous mudstone, siltstone, and sandstone.	4300-4985	685

Pleistocene 0-35 feet

Lithology

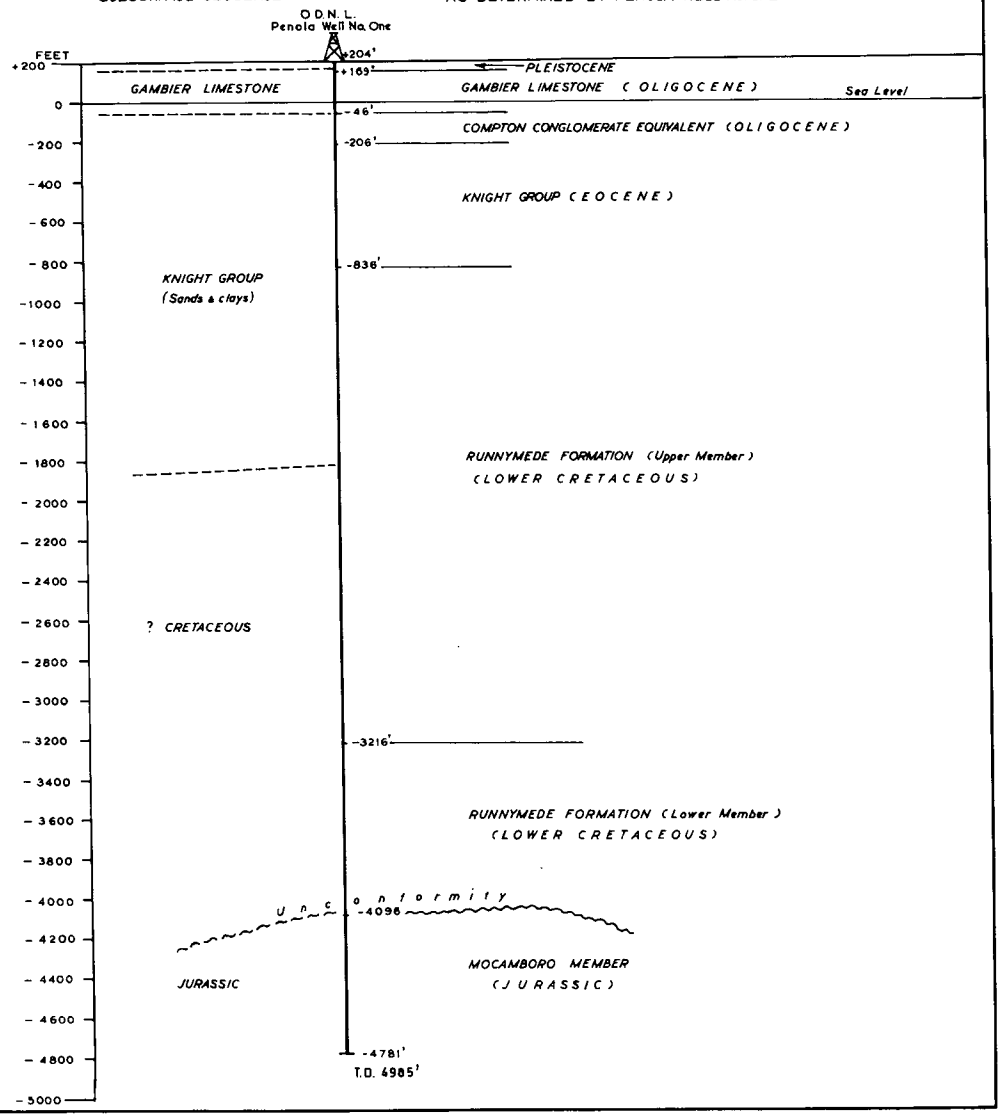
Sandstone, white and brown, medium-grained, calcareous with minor loose medium to coarse sand and dark brown limestone.

Palaeontology

Foraminifera "Rotalia" beccarii and species of "Elphidium". (see Appendix 2).

Fig.2

SUBSURFACE SEQUENCE AT O.D.N.L. PENOLA WELL No.ONE



Electrical characteristics

No logs were run over this interval.

Oligocene (Gambier Limestone) 35-250 feet

Lithology

White bryozoal limestone.

Palaeontology

Dr. N.H. Ludbrook of the Department of Mines, South Australia, records Victoriella "plecte" (= conoidea) from this unit, as well as an associated foraminiferal assemblage. (see Appendix 2).

Electrical characteristics

No logs were run over this interval.

Oligocene (Compton Conglomerate Equivalent) 250-410 feet

The selection of the boundary between the Compton Conglomerate equivalent and the overlying Gambier Limestone is very much in doubt because no samples were obtained over the interval 300 - 503 feet. It is in this interval that the boundary probably lies.

A tentative boundary was selected as being approximately mid-way at 410 feet. In attempting to correlate with the Penola school bore it was seen that this tended to give an anomalous thickness to the Compton Conglomerate equivalent and that a better depth for this boundary may be at approximately 300 feet, as has been suggested by Dr. N.H. Ludbrook. (see Appendix 2).

Lithology

Sand, clear to pale orange coloured, fine to medium-grained, subangular to subrounded, fairly well sorted. Well rounded ironstone grains also present.

Palaeontology

Abundant Cassidulina subglobosa associated with other foraminifera. (see Appendix 2).

Electrical characteristics

No logs were run over this interval.

Eocene (Knight Group) 410-1040 feet

Lithology

Sand, medium to very coarse grains of subrounded clear and smoky quartz and in places blue-grey, dark grey and black chert. Pebbles of quartz and chert occur in some intervals as well as traces of pyrite, mica and carbonaceous matter. Minor clay inter-beds

may also be present, these being difficult to distinguish as the clay becomes mixed with the drilling fluid. The unconsolidated nature of the sand is indicated on the caliper log which shows considerable caving to maximum of 13" (bit size 8 1/2") between 550 and 800 feet.

Palaeontology

Plant remains, and pyritized wood fragments. Dr. N.H. Ludbrook records one pyritized test of Cyclammina sp. at 905 - 910 feet. (see Appendix 2).

Electrical characteristics

The Restivity curves are characterized by high values, with deeper penetration curves showing the highest values, a phenomenon typical of fresh water sands. Good porosity is indicated on the Micrologs. The S.P. curve shows a relatively high constant value.

Lower Cretaceous (Runnymede Formation - Upper Member) 1040 - 3420 feet

Lithology

Interlaminated and interbedded mudstone, siltstone and sandstone.

The mudstones vary from grey, greenish-grey and dark grey in colour, and are generally silty, finely micaceous and contain carbonaceous flecks, and in places, inclusions of coaly material (including needle coal). Mudstone pellets are present at some intervals and a few specks of white, chalky limestone are included in the mudstone between 1555 and 1600 feet. Traces of pyrite are present at intervals throughout the section.

The siltstones are generally somewhat lighter in colour, ranging from light grey, grey to greenish-grey.

In places the siltstones have a kaolinitic cement and traces of altered feldspars are present. Generally the matrix is argillaceous material similar to the mudstones described above. Carbonaceous and coaly flecks, mica, chlorite and in places pyrite, are present in the siltstones.

Current-bedding and slump structures become increasingly evident in the cores taken toward the lower part of this unit, as indicated by siltstone laminations, lenses and beds, and also by the laminar concentration of carbonaceous material.

The silty mudstones and siltstones often grade imperceptibly into each other.

The sandstones generally are grey, fine-grained, poorly sorted, subangular and subrounded and have the same accessories as the siltstones of which they appear to be a coarser grained phase in many places. In the upper parts of this section loose quartz grains are commonly present in the cuttings samples, but these are probably mostly cavings from the overlying sands of the Knight Group.

Below 2290 feet the sandstones, and to a large extent the siltstone interbeds, are calcareous in a number of places. The best developments occur between 2290 and 2405 feet and between 2610 and 2735 feet. The calcareous sandstone interbeds are generally grey, fine-grained and hard; they grade in places to sandy limestones and contain rare traces of glauconite in the lower interval. There is some evidence of minor marine incursions (see Appendix 2) within the limits 2586 - 3195 feet.

A number of sandstones and siltstones of the Upper Member of the Runnymede Formation are porous (see Composite Well Log, Plate 1). The best development of porosity is over a 16-foot interval in a sand between 3189 and 3205 feet.

Although a great deal of coaly and carbonaceous matter, as well as some carbonaceous shales are present in the Uppper Member of the Runnymede Formation, no discrete coal seams were identified.

A few fragments of pale brown, fine crystalline limestone appeared in the samples from some horizons. In the 2105-2110-foot sample some of these fragments had a vaguely fragmental fossiliferous appearance. Although there is a fair amount of irregular current-bedding, the bedding observed from cores appears to be generally flat.

Thin section examination and Soxhlet oil extraction test was made from a portion of Core No. 7, 2380-2390 feet (see Appendix 6).

Palaeontology

Dr. N.H. Ludbrook has identified megaspores of the water fern Azolla or allied genus between 1200 and 3373 feet, indicating a Lower Cretaceous age, and has recorded a fish tooth from Core No. 8, 2586 to 2596 feet, a reptilian or amphibian tooth from Core No. 11, 3180 to 3190 feet, and occasional foraminifera between 2586 - 3195 feet (see Appendix 2). Mr. J. Douglas of the Department of Mines, Victoria, examined an impression from Core No. 7, 2380 - 2390 feet, which showed some characteristics of certain Mesozoic fern-like foliaged plants. Mr. Douglas also records a depauperate microflora including the gymnosperm pollens Cingulatisporites and Cyathidites sp. from the same core (see Appendix 4).

Dr. Isabel C. Cookson of the Botany Department, University of Melbourne, also examined Core No. 7, 2380 - 2390 feet, and records an assemblage of microspores of Lower Cretaceous age.

Dr. P.R. Evans of the Bureau of Mineral Resources, records microspores and very rare microplankton from Core No. 8, 2586 - 2596 feet, suggestive of a Lower Cretaceous (? Albian) age (see Appendix 3).

Electrical characteristics

The S.P. curve shows a great deal of detailed character, in contrast to the constant high value of the Knight sands above and relatively low values of the Lower Member of the Runnymede Formation. Fluctuations of the S.P. curve have a maximum range of 60 millivolts, with an average range of about 30 millivolts above 2410 feet. The magnitude of the fluctuations decreases below 2410 feet, except for a few beds of sandstone.

The 16" normal resistivity curve is somewhat lacking in character and except for a few hard streaks and some sandstone and siltstone beds, is generally between 1 and 2 ohms. The deeper penetration resistivity curves read lower than the 16" curve in sandstone and siltstone, indicating salty formation water behind the invaded zone. The resistivity curves are in marked contrast to the very high values in the fresh water Knight sands above, and do not have the number of sharp high resistivity kicks given by the coal seams and grit beds of the Lower Member of the Runnymede Formation.

The Microlog-Caliper log indicates a number of porous sandstones and siltstones (see composite log), with filter cake build-up opposite the porous sections.

Lower Cretaceous (Runnymede Formation - Lower Member) 3420-4300 feet

Lithology

Coal measures (interbedded mudstones, shale, siltstones, sandstones and coal seams) overlying a section containing interbeds of grit.

The coal measures have a thickness of 520 feet and a total of 24 discrete seams of coal were identified from sample and log studies. The maximum thickness of any individual seam is 5 feet, the minimum thickness of any seam identified is 1 foot, and the average thickness of identified seams is 2.7 feet. A number of seams less than 1 foot thick may also be present but too thin for identification. The aggregate thickness of the coal seams within the coal measures is indicated on the composite well log (Plate 1). In places the coal is bright, brittle with a conchoidal fracture and is generally associated with black carbonaceous shale beds.

The coal seams occur in an interbedded and interlaminated sequence of mudstones, siltstones and sandstones similar to those in the Upper Member of the Runnymede Formation. Black carbonaceous mudstones and shales are also present, as well as traces of slightly calcareous brown claystone and ironstone. The mudstone near thee top of the sequence contains, in places, fine specks of gibbsite. The sandstones are commonly calcareous and in places contain siderite. Minor pale brown, fine crystalline limestone containing coaly flecks is present at 3510 feet.

Below the coal measures between 3940 and 4300 feet thin beds of grit and coarse-grained angular sandstone occur as interbeds in a sequence of grey, silty, micaceous, carbonaceous mudstones, grey, micaceous, carbonaceous siltstones and whitish-grey, fine-grained kaolinitic sandstone. These beds are friable and were recovered in the cuttings only as loose angular quartz grains rarely cemented with kaolin. A 1" bed of grit was recovered in Core No. 17, 4082 - 4092 feet, where it consisted of subangular, clear and grey quartz generally 2-3 mm in diameter, cemented in many places with white kaolin, grading to altered feldspar fragments in a few places. A thin section study indicates that this gritty material has the texture and mineral composition of granite.

There appear to be eight beds of grit, from 1 to 3 feet thick, between 3939 and 4039 feet and a few very thin interbeds, possibly only a few inches thick, probably persist down to 4300 feet. As the grits and coarse sandstone are friable and probably susceptible to caving, 4300 feet is rather an arbitrary pick for the base of these beds. As the grits were recovered in the cuttings only as loose grains, and no microlog could be run over this section, no estimate could be made of the porosity. However, using an assumed porosity the electrical characteristics of a 3-foot bed at 3980 feet indicated the possible hydrocarbon content. A drill stem test, including this interval, however, recovered only 16 feet of mud, indicating ineffective permeability.

From the base of the main grit beds at 4039 feet to the assumed top of the Jurassic unconformity, the sequence contains a high proportion of siltstone to very fine-grained sandstone which is light grey to grey-brown, micaceous, kaolinitic to slightly calcareous, and containing some carbonaceous flecks. These beds are interbedded with grey mudstone as previously. Mud pellets are present in the core cut from 4082 - 4092 feet, as well as a thin, brown claystone bed, and numbers of calcite veinlets.

The bedding in the Lower Member of the Runnymede Formation is generally flat, although current-bedding and minor slump structure are evident.

Palaeontology

Dr. P.R. Evans, from his palynological studies, considers that beds between Cores 12 and 15 (3363 - 3928 feet) were deposited mainly in Aptian and perhaps partly in Albian times (Appendix 3). Mr. J. Douglas records fragmentary remains of Thinnfeldia pinnata and

Taeniopteris spatulata from Core No. 15, 3917 - 3928 feet, and implies doubt as to whether these forms indicate a Lower Cretaceous or Jurassic age (see Appendix 4).

Electrical characteristics

The S.P. curve is at a relatively low level and rarely shows fluctuation in excess of 10 millivolts except in the grit and sand beds around 4000 feet, where sharp fluctuations with a range of up to 45 millivolts are indicated. A slight drop in S.P. value is apparent adjacent to coal seams. The resistivity curves are characterized by high value thin peaks adjacent to coal seams and the grit and sand beds around 4000 feet. The Micrology-Caliper survey could not be run over this interval.

Jurassic (Mocamboro Member) 4300 - 4985 feet

There is some doubt whether this interval is Jurassic or Lower Cretaceous.

The beds of this section have average dips of between 10^{o} and 18^{o} in contrast to the essentially flat lying beds above.

Lithology

Interbedded and interlaminated mudstones, siltstones and sandstones.

The mudstones are generally grey, greenish-grey, silty, micaceous and in places contain carbonaceous flecks. The siltstones are light to medium grey, kaolinitic, micaceous and contain carbonaceous flecks in places.

The sandstones are whitish-grey, kaolinitic, fine-grained, and are generally micaceous. In places laminations due to concentration of mica flakes are present. Both the siltstones and sandstones have an arkosic appearance in places. Traces of poor porosity are evident in a few samples. Near the top of the unit a few loose, coarse, subangular quartz grains are present in some samples. These may be due to cavings from the coarse sandstone beds above. Near the base of the section minor interbeds of fine, medium and coarse-grained, whitish-grey quartz sandstone appear to be part of the section. Minor beds of dark grey to black, very micaceous shale are also present near the base of the section.

Palaeontology

Dr. N.H. Ludbrook records Taeniopteris spatulata from Core No. 19,4390-4400 feet, and Taeniopteris spatulata and Thinnfeldia sp.from Core No. 20,4600-4619 feet, and considers these beds to be possibly of Jurassic age (Appendix 2). Mr. J. Douglas also records Taeniopteris spatulata from Core No. 19, 4390-4400 feet (Appendix 4). Mr. Douglas also discusses the opinions of other authors concerning a Jurassic or Lower Cretaceous age for a flora containing Taeniopteris and Thinnfeldia pinnata. Dr. P.R. Evans discusses in some detail the Lower Cretaceous-Jurassic problem with regard to beds below 4390 feet, in his palynological report (Appendix 3). Mary E. White discusses Taeniopteris specimens from Core No. 19, 4390-4400 feet, considering them to be either Jurassic or Lower Cretaceous in age (Appendix 4).

Electrical characteristics

No logs were run over this interval.

Structure:

Above the Jurassic unconformity the beds are generally horizontal, below they show a very low angle dip. Evidence of a minor, very low angle fault is present in Core No. 19 at 4397 feet.

Relevance to Occurrence of Petroleum:

Minor showings of gas were encountered at Penola No. 1, none being of commercial significance. Very slight bubbling of gas from low porosity sandstone was observed in a core taken at 4600 feet. A drill stem test was attempted over this interval but a satisfactory packer seat could not be obtained, and the low porosity did not warrant persevering with this zone any further.

The Electric logs indicated that a 3-foot sand at 3980 feet possibly contained hydrocarbons. However, a drill stem test covering this interval recovered only 16 feet of drilling fluid.

A gas-air sample collected while circulating at 4000 feet was analysed and found to contain a small amount of hydrocarbon gas consisting of 98.9% methane with 1.1% of higher hydrocarbons, which indicates a probable coal seam source (see Appendix 5).

The well indicates that the structure does not contain hydrocarbons in commercial quantities above 4985 feet.

Porosity and Permeability of Sediments Penetrated:

As mentioned in discussion of the lithology, various porous beds are present in the section penetrated. These are also illustrated on the composite log. The Knight fresh water sands have generally good to excellent porosity. Numerous beds of sandstone and siltstone in the Upper Member of the Runnymede Formation exhibit porosity ranging from trace to good, the maximum porous thickness in any one bed being 16 feet. The Runnymede sandstones and siltstones are salt water saturated. Traces of generally poor porosity are present in some minor sandstone beds in the Jurassic. Porosity and permeability determinations are shown in Appendix 10.

Contributions to Geological Concepts Resulting from Drilling:

As a result of drilling it is now known that the Eocene-Lower Cretaceous contact (i.e. base of the Knight Group) at 1040 feet is considerably higher than anticipated before drilling. As there are very few places that the Knight Group has been penetrated before in the area south of the Lucindale fault, this information will become very useful as further drilling is undertaken in this area.

The Lower Cretaceous is now known to be dominantly non-marine in this part of the basin. No other well in this area had previously penetrated this sequence. The possible existence of an unconformity at about 4200 feet, as interpreted from the seismic data appears to be supported by the change in lithology from the coal measures and frequent beds of grit underlying them in the lower part of the Lower Cretaceous sequence to the monotonous dominantly carbonaceous shale and siltstone sequence of the Jurassic Mocamboro Member. Further support for this interpretation is afforded by the dips in the cores which are flat-lying down to 4082 feet but range from 10 to 18 degrees below 4390 feet.

The dips as seen in cores throughout the section are generally in accord with those shown on the seismic section at the location where the well was drilled. The palynological data were insufficient to establish any sharp change in character between the assemblages of the Runnymede Formation and the Mocamboro Member, but Dr. P.R. Evans reported (Appendix 3) that "Core No. 21 provided a low yield of microspores which suggested an age either very low in the Cretaceous or possibly very high in the Upper Jurassic".

A systematic breakdown of the Lower Cretaceous-Jurassic sequence in the Penola area is now possible.

The marine Upper Cretaceous sediments penetrated in the Nelson Bore are now known to be absent in the Penola area, where Tertiary sediments overlie a Lower Cretaceous sequence comparable to that at Robe.

Samples from Comaum Bore at 651 feet and 708 feet and Loxton Bore at 1410-1476 feet approach Penola No. 1, Core No. 8 in age (see Appendix 3).

The penetration of nearly 5000 feet of sediments in the Penola area has added a great deal of lithologic detail to the geologic knowledge of this part of the Gambier Sunklands.

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APPENDIX 1

DESCRIPTIONS OF CORES

Core No. 1: Cored interval 1200 - 1210 feet. Recovery: 30", 25%

Finely interlaminated and interbedded argillaceous siltstone, silty shale and fine-grained argillaceous sand. The siltstone is light grey, slightly argillaceous, with scattered mica, carbonaceous flecks and rare chlorite. The shale is medium to dark grey, soft, very silty with occasional mica. The sand is medium grey, fine-grained, soft, friable, slightly argillaceous, fairly well-sorted; subrounded, clear to dark grey quartz grains, with carbonaceous shale fragments, traces of mica, rare trace chlorite and glauconite.

Dip of bedding: Generally flat lying.

Samples collected while coring indicate that the interval 1200 - 1210 feet is of similar lithology to that of the recovered core.

Core No. 2: Cored interval 1410 - 1418 feet. Recovery: 24", 25%

Siltstone, medium grey, fairly soft and friable, micaceous, scattered dark grey quartz grains, with minor irregular inclusions and lenses of shale, brownish-grey, silty, micaceous. Siltstone is weakly cemented with a light, possibly kaolinitic clay, probably partly washed out by mud filtrate. Some slight intergranular porosity under high power examination.

Dip of bedding: Indeterminable.

Samples from cored section:

1400 - 1405 feet. As for sample 1395 - 1400 feet. Silty shale probably dominant. Trace mica.
1405 - 1410 feet. As above. Silty shale probably dominant. Trace pyrite.
1410 - 1415 feet. As above. Argillaceous siltstone probably dominant.
1415 - 1418 feet. As above. Argillaceous siltstone probably dominant.

Core No. 3: Cored interval 1610 - 1620 feet. Recovery: 30", 25%

Thinly interbedded and interlaminated shale and siltstone. The shale is dark grey to greenish-grey, soft, slightly silty to silty, micaceous. The siltstone is medium grey to slightly greenish-grey, argillaceous, with occasional carbonaceous flecks. Scattered dark shale particles and dark brownish-grey, very soft, waxy textured ovoid mudstone fossil casts (?) from 0.5 mm to 5 mm in diameter are present in both shale and siltstone.

Dip of bedding: Probably flat lying.

Samples from 1610 - 1620 feet were collected when reaming out pilot hole cut by the core barrel.

1610 - 1620 feet. Trip samples after shut down period of 1 1/2 days while installing B.O.P. consisted of a clay-mud mixture. Rock type probably mainly shale, medium grey, silty, micaceous.

Core No. 4: Cored interval 1805 - 1815 feet. Recovery: 24", 20%

Mudstone, greenish-grey, silty, weakly micaceous, grading in places to siltstone, medium grey, argillaceous, micaceous. Contains carbonaceous flecks, some large inclusions of

carbonaceous shale, and occasional coal fragments, some acicular.

Dip of bedding: No bedding or laminations observed.

Samples from cored interval showed chips of the formation seen in core except that in sample from 1810 - 1815 feet a trace of pyrite was seen.

Core No. 5: Cored interval 2010 - 2020 feet. Recovery: 22", 18%

Mudstone, 12", grey with laminations and layers up to 1/4" thick, with dark grey mudstone tending to siltstone in lighter coloured sections; very slightly micaceous. Few small carbonaceous flecks. Vertical 1/16" diameter worm burrows filled with sand grains.

Sandstone, 4", semi-consolidated, light grey, composed of ill-sorted angular, clear, blackish, and grey fine-grained quartz. Trace of mica and pyrite.

Mudstone, 6", tending to siltstone, grey, very slightly micaceous and with a few minor carbonaceous specks.

Dip of Bedding: Indeterminable.

Samples from cored section:

2010 - 2015 feet. Chips of mudstone as above, few chips of sandstone as above.

2015 - 2020 feet. As above.

Core No. 6: Cored interval 2200 - 2210 feet. Recovery: 4'2", 42%

Mudstone, 8", grey, fairly hard, slightly silty, very slightly micaceous, with a few scattered pieces of coaly material.

Siltstone, 18", grey, composed of subangular clear, smoky and dark grey quartz, with specks of mica and rare carbonaceous flecks.

Mudstone, 24", as above but less silty, and with small (up to 1/16") clay pellets. Vertical fracture seen. Slickensiding noted, probably a compaction effect.

Dip of bedding: Apparently flat.

Core No. 7: Cored interval 2380 - 2390 feet. Recovery: 34", 28%

Mudstone pellets, 2", from 2 mm to 1 cm in diameter, varying in shades of green and grey, texture, hardness and silt content, in a silty greenish-grey clay.

Sandstone, 3", very fine-grained, friable, non-calcareous, with scattered dark grey quartz grains. Trace of coaly flecks, mica flakes and pink quartz grains.

Mudstone, 29", with varying silt content, greenish-grey, weakly micaceous, scattered fine specks of carbonaceous and coaly material, interlaminated and interbedded with greenish-grey argillaceous siltstone, also with specks of carbonaceous and coaly material. Over a 2" interval, 10" from the top of this section, the mudstone contains numerous flecks and lenses of coal, generally aligned along the bedding, to a maximum of 2 cm long and 4 mm thick. Over a 2" interval, 21" from the top of this section, are greenish-grey mudstone pellets similar to those at the top of the core. The pellets in this case are generally about 3 mm in diameter,

in a silty mudstone matrix containing carbonaceous flecks. Underlying this pellet zone are several lenses of coal 2 cm long and 3 mm thick.

Dip of bedding: Generally flat, although numerous miniature slump structures are present in the upper part of the core. One vertical fracture noted.

Sample from cored section:
2385 - 2390 feet. Mudstone, grey, slightly micaceus, with occasional carbonaceous flecks. Siltstone, grey, arenaceous, micaceous, grading to ill-sorted very fine-grained sandstone composed of angular clear, smoky and black quartz grains. Trace of coal and pyrite. A few loose quartz grains.

Core No. 8: Cored interval 2586 - 2596 feet. Recovery: 7 feet, 70%

Siltstone, 2'10", grey, very argillaceous and very finely micaceous, dense, with rare specks of coal and carbonaceous matter. Some laminations dip at 2^{o} - 5^{o} and contact with mudstone below is at about 8^{o}.

Mudstone, 4'2", dark grey to black, slightly fissile, very finely micaceous and with coal fragments. One zone 3" long at 22" from top of section has several lenticular areas of greyish-buff mudstone, irregular in size and shape.

Dip of bedding: About 5^{o}.
Samples from cored section:
2585 - 2590 feet. Mudstone, medium grey and dark grey, finely micaceous, grading to siltstone. Trace of carbonaceous matter and rare chips of grey sandstone.
2590 - 2596 feet. As above.

Core No. 9: Cored interval 2790 - 2798 feet. Recovery: 4 feet, 50%

The entire core recovery consists of subrounded pebbles of mudstone in a drilling mud matrix. Rock types in the recovered pebbles were as follows: Mudstone, greenish-grey, micaceous, slightly silty in places, and occasionally grading to siltstone. Scattered carbonaceous flecks with fine, light brown, non-calcareous spots in a few places. Mudstone, light brownish-grey, generally not as silty as above, but with more carbonaceous material in places as laminations, and a trace of mica.

Dip of bedding: Indeterminable.
Samples from cored section:
2790 - 2795 feet. Mudstone, grey to greenish-grey, slightly silty in places, with traces of carbonaceous flecks, slightly micaceous. Sandstone (5%), tight, fine-grained, hard, calcareous, scattered carbonaceous grains, trace coarse mica, trace red specks. Traces of shale, coal inclusions, and white specks in places.
2795 - 2800 feet. Mudstone as above, more silty, and grading in places to siltstone. Trace of coaly laminations and black carbonaceous shale.

Core No. 10: Cored interval 2990 - 3000 feet. Recovery: 5' 6", 55%.

Rubbly material in drilling mud matrix, 4' 6", possibly due to coring in fractured zone. Coarse subrounded pebbles of mudstone, greenish-grey, silty, grading to siltstone, micaceous, with some carbonaceous flecks and minor black carbonaceous shale fragments.

Sandstone, 1'2", light to medium grey with slight greenish tint, very fine-grained, poor to fair sorting, with subangular clear to grey quartz grains. Brown mica common in places as coarse flakes. Fine red grains, as well as green grains, some probable chlorite, are present in minor amounts. Grains of vitrain-like coal and carbonaceous shale are fairly common. In places carbonaceous material is concentrated in dark grey laminae. The sandstone is moderately calcareous, tight, and with indistinct traces of current-bedding.

Siltstone, 4'4", argillaceous, current bedded. Light, medium and dark grey laminations and thin beds, with colour variations due to varying amounts of carbonaceous material. In addition to laminations there is a scattering of carbonaceous material throughout, with brown mica and occasional red and green grains.

Dip of bedding: Apparently flat-lying.

Samples from cored section:

2990 - 2995 feet. Mudstone, medium grey with some dark grey and few chips with purple tint, silty in places, few carbonaceous specks, very slightly micaceous. Few pieces of grey, speckled, fine-grained, slightly calcareous, porous sandstone.

2995 - 3000 feet. As above.

Core No. 11: Cored interval 3180 - 3190 feet. Recovery: 5 feet, 50%

Fragmentary mudstone, 6", apparently in drilling mud matrix; mudstone is grey-green and micaceous, with coal fragments. Some fragments vary to fine-grained quartzose sandstone, still micaceous and with rare coal fragments.

Fine-grained sandstone, 4 feet, medium grey, speckled appearance with scattered black carbonaceous grains, quartz grains and with white crystalline cement. Sporadic lenses of medium-grained subangular quartz grains. Tight at 3185 - 3186 feet, but becoming more porous to very porous at 3188 - 3189 feet; some current-bedding at 3187 feet. Quartz grains subangular to rounded, moderately well sorted.

Fine-grained grey, tight calcareous quartzose sandstone, 6". Quartz particles subangular.

Dip of bedding: Indeterminable.

Samples from cored section:

3180 - 3185 feet. Mudstone, grey, slightly micaceous, grading to siltstone. 25% sandstone, greenish-grey, very fine-grained, composed of clear, white, smoky, very pale green, and black subangular quartz grains, poorly sorted, slight porosity. Traces of coal and buff clay.

3185 - 3190 feet. As above, with some slightly coarser fragments of fine-grained sandstone and green-grey mudstone with some calcareous sandstone.

Core No. 12: Cored interval 3363 - 3373 feet. Recovery: 18", 15%

Reaming rubble (mostly mudstone), 5 feet, in drilling mud matrix.

Mudstone, 18", medium grey, silty, micaceous, with carbonaceous flecks, coaly grains and rare traces of chlorite. Numerous fine laminations of carbonaceous material, and irregular lenses and blebs of lighter grey argillaceous siltstone, with carbonaceous flecks and coaly grains. Many irregular miniature slump features.

Dip of bedding: About 3° (unreliable).

Sample from cored section:

3370 - 3375 feet. Mudstone, medium grey, silty, slightly micaceous, with coaly laminae in places.

Core No. 13: Cored interval 3514 - 3524 feet. Recovery: 6 feet, 60%

Mudstone, 12", medium grey, very slightly micaceous, with few isolated carbonaceous specks.

Mudstone, 3", as above but with thin layers of coal. Maximum thickness of coal 1/2" and average thickness less than 1/32".

Mudstone, 14", as above with specks of rare white, finely crystalline soft mineral.

Mudstone, 5", as above but with slickensides at approximately 45°.

Mudstone, 4", as above with increase in amount of white mineral. Burrow about 1" long filled with white mineral, at right angles to bedding.

Mudstone, 6", with thin laminae of coal increasing to bottom of section, where there is a layer of pure coal 1/4" - 1/2" thick.

Mudstone, 26", as above with specks of white mineral.

Mudstone, 2", as above with irregularly shaped blebs of buff clay.

Dip of bedding: Generally flat-lying.

Core No. 14: Cored interval 3715 - 3729 feet. Recovery: 7 feet, 50%

Mudstone, 3'3", dark grey-black grading to greenish-grey near base, very slightly micaceous, with very finely divided carbonaceous material throughout, as well as abundant coarse fragments of coal (including acicular fragments) and carbonaceous flakes in the lower 16". The lower 4" shows two sets of fractures at about 45°, with associated slickensiding. One quartz pebble, rounded, 1/4" diameter, at point 18" from top of core.

Sandstone, 8", pale grey, very fine-grained, tight, composed of white, clear, black and pale green, subrounded, fairly well sorted quartz grains with rare mica specks. Current-bedding present. Becomes argillaceous towards base of section.

Mudstone, 2 1/2", black, carbonaceous, slightly micaceous and contains one 1/4" diameter quartz pebble.

Interbedded sandstone and siltstone, 2' 1 1/2", thin layers and laminations of sandstone, light grey, very fine-grained, argillaceous, slightly micaceous, interbedded with dark grey siltstone, arenaceous, micaceous, slightly carbonaceous. Sandstone and siltstone show current-bedding, slump structures, flow structures, scour and fill structures.

Sandstone, 9", light grey, fine-grained, well sorted, with calcareous cement, scattered specks of carbonaceous material and rare specks of mica. Towards base of section lenses up to 1/8" thick of pale buff, calcareous claystone with scattered carbonaceous specks.

At base of section 1/2" layer of claystone as before but laminated with slightly lighter coloured clay.

Dip of bedding: Generally flat, but some current-bedding and scour and fill structures.

Core No. 15: Cored interval 3917 - 3928 feet. Recovery: 26", 20%

Siltstone, grey, argillaceous, calcareous in top 6". Scattered grains of coal, very fine grains of white mineral, brown and white mica, and siderite in places. Contains irregular lenses and laminations of slightly darker grey silty mudstone with same accessories, as well as dark grey to black laminations of carbonaceous material. Some recognizable leaf remains, generally as coal, but in places replaced by brown sideritic (?) material.

Dip of bedding: Generally flat but with some slumping and current-bedding.

Sample from cored section:
3925 - 3930 feet. 60% Mudstone, light grey, micaceous, and with rare flecks of coal.
30% Siltstone, grey, white cement, coal flecks common.
10% Sandstone, calcareous with white cement, subrounded to subangular fragments including some coal, and traces of carbonaceous matter.

Core No. 16: Cored interval 3957 - 3962 feet. Recovery: Nil

Core No. 17: Cored interval 4082 - 4092 feet. Recovery: 7' 8", 73%

Granitic pebble, 1".

Mudstone, 5 1/2", with mudstone pellets up to 5 mm in diameter and 3 mm thick in matrix of mudstone, partly silty. The pellets are greenish-grey, with rare black specks, probably of coal. The matrix is greenish-grey, and micaceous, with few specks of coal. Subrounded, medium-grained quartz particles are scattered throughout, and fragments of plants and coal are common.

Mudstone pellets, 1", with little or no matrix, quartz grains rare.

Mudstone, 6", similar to the 5 1/2" above but slightly less silty and greener. Mudstone pellets larger, up to 1 cm diameter and 5 mm thick. Slickensides at 40° near the top of this section.

Claystone, 4 1/2", light brown, silty, hard, very sideritic, with fractures filled with veinlets up to 2 mm thick part calcite, part siderite as well as in places, kaolin, hematite, and pyrite. Scattered coarse subangular to subrounded clear and grey quartz grains and inclusions of coal.

Siltstone, 14", dense, grey, micaceous, with fragments of coal and pyrite common.

Siltstone, 4 feet, grey, micaceous, laminated and current bedded, with common fragments of coal.

Three soft, dark grey clay bands, each 1" thick are present in this unit; the clay is slightly micaceous with rare rounded quartz grains.

Siltstone, 1 foot, as above but with intersecting veins of calcite.

Dip of bedding: Flat-lying.

Samples from cored section:

4082 - 4085 feet. Mudstone, grey, greenish-grey, dense texture, silty in places, grading to a siltstone which is light grey, argillaceous, slightly micaceous, occasionally flecked with coal. Loose subrounded to subangular coarse quartz grains - pebbles maximum 6 mm diameter. Trace fine to medium-grained slightly calcareous quartz sandstone, very badly sorted with pellets of blue dense-textured mudstone.

4085 - 4087 feet. As above. Increased proportions of siltstone (25%). Maximum diameter of quartz pebbles 4 mm. Trace of sideritic claystone.

4087 - 4092 feet. As above. Trace of black carbonaceous shale.

Core No. 18: Cored interval 4270 - 4280 feet. Recovery: 4", 3%

Mudstone, 4", medium grey, micaceous in places.

Dip of bedding: Indeterminable.

Samples from cored section:

4270 - 4275 feet. Mudstone, medium grey, very silty in places, with traces of coal, more micaceous than previously, and in places laminated with light grey, argillaceous, micaceous, siltstone, slightly kaolinitic, with flecks of coal and grains of greyish-green material. Traces of black carbonaceous shale.

4275 - 4280 feet. Mudstone as above, also with sandstone, very fine, tight, very light grey, micaceous, kaolinitic, with occasional very fine pellets of green talcose mudstone, and rare traces of black carbonaceous shale.

Core No. 19: Cored interval 4390 - 4400 feet. Recovery: 10 feet, 100%

Mudstone, 4' 3", dark grey, finely micaceous, with few plant remains and rare fragments and lenses of coal to a maximum of 1/8" thick. Lenses of lighter grey mudstone in lower 3 feet show numerous small scale slump structures but the overall dip is about 10^{o}.

Mudstone, 2' 4", medium to dark grey, weakly micaceous, with scattered white non-calcareous specks throughout. Lower 12" contains abundant green, greenish-grey, and occasional brown mudstone pellets up to 1/4" diameter.

Breccia, 2", angular fragments of dark grey, slightly micaceous mudstone up to maximum of 1/4" across in matrix of slightly silty grey-brown clay.

Clay, 10", grey-brown, unconsolidated, plastic when wet.

Breccia, 1", as previously, mudstone fragments somewhat smaller.

Mudstone, 17", medium-dark grey, slightly micaceous, irregular fractures common, and occasional white, non-calcareous specks throughout.

Clay, 1", grey-brown, as described in previous 10" section.

Mudstone, 10", medium to dark grey, slightly micaceous, slightly silty in a few places, and with occasional white non-calcareous specks; many irregular fractures, in places filled with calcite.

Dip of bedding: 10^{o}.

Core No. 20: Cored interval 4600 - 4619 feet. Recovery: 19 feet, 100%

Interbedded sandstones and siltstones, 3 feet. Sandstone is alternately very light grey and dark grey, fine to very fine-grained, micaceous, calcareous cement, with subrounded, clear and pale green quartz grains. The dark grey variety is heavily micaceous with white, brown and black micas, together with rare carbonaceous grains and specks of carbonaceous matter. The sandstone contains small layers and lenses of dark grey micaceous quartzose siltstone.

Sandstone, 5 feet, very pale grey, fine to medium-grained, slightly micaceous, calcareous cement, with some pale green, subrounded, ill-sorted quartz grains. Contains bands of current bedded and laminated dark grey and light grey siltstone up to 1" thick. Over a 2-foot interval commencing one foot from the top of this unit, slight traces of very poor porosity are present, and very faint bubbling was noted from the freshly pulled core.

Interbedded siltstone, sandstone and mudstone, 2 feet. Argillaceous siltstone, interbedded, interlaminated and interlensed with sandstone as above, but non-calcareous and with a little mudstone. Current-bedding and slump structures are very prominent.

Sandstone, 2' 4", whitish-grey, medium-grained, composed of clear, and a few pale green quartz grains in calcareous cement, ill-sorted, micaceous and containing a few minute pieces of coal. Thin laminae of siltstone dipping at 30^{o} are present. At the top of this unit thin lenses and hairlike inclusions of coal are present, together with rounded (1/4" diameter) pale brown claystone pellets. At the base of the unit a 6" zone contains medium brown pellets of claystone.

Siltstone, 1' 8", dark grey, very argillaceous, micaceous, interbedded with dark grey silty mudstone, slightly carbonaceous, but with several plant remains preserved as coal.

Shale, 12", black, very carbonaceous, with laminae of coal.

Siltstone, 4 feet, medium grey, argillaceous, micaceous and with scattered small pellets of black shale at top of section. Becomes increasingly interlaminated, interbedded and interlensed with very fine-grained sandstone, exhibiting slump and current-bedding structures.

Dip of bedding: Ranges from 10^{o} - 30^{o} in core; average dip 18^{o}.

Core No. 21: Cored interval 4766 - 4776 feet. Recovery: 6 feet, 60%

Sandstone, 1", current bedded, light grey, poorly sorted kaolin cement, micaceous, argillaceous, laminated due to concentration of brown, black and white mica in matrix of argillaceous silt and sand.

Clay, 7", dark grey, soft, plastic when wet, with scattering of silt size quartz grains.

Sandstone, 4", current bedded, with strong dark coloured laminations in current-bedding.

Clay, 8", as previously, with some thin beds of sandstone up to 3/4" thick.

Sandstone, 3", current bedded, similar to previous sandstone.

Clay, 4", similar to previous clay.

Sandstone, 3' 9", light grey, fine-grained, somewhat friable, generally poorly sorted, with kaolin cement; abundant dark grey laminations show current-bedding and slump structures. Dark grey laminations consist of strong concentrations of brown and black mica in silty sand matrix, with rare coal grains and flecks, and occasional fragments of dark grey, argillaceous, micaceous siltstone. Sandstone generally somewhat friable and some thin bands have been washed out in core giving a pitted appearance.

Dip of bedding: Current bedded, but average dip is about 13^{o}.

Samples from cored section:

4765 - 4770 feet. 95% Mudstone as above
5% Sandstone as above.
Trace of brown and black carbonaceous shale.

4771 - 4776 feet. 75% Mudstone as above.
10% Siltstone.
15% Sandstone and occasional coarse, loose, subrounded quartz grains.

APPENDIX 2

O.D.N.L. PENOLA NO. 1 WELL

SUBSURFACE STRATIGRAPHY AND MICROPALAEONTOLOGICAL STUDY

by

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ABSTRACT

Beneath a thin Pleistocene cover, Penola No. 1 Well penetrated a sequence of marine and paralic Tertiary and marine and non-marine Mesozoic rocks ranging in age from Oligocene to (?) Upper Jurassic. The Tertiary sediments consisted of 215 feet of Gambier Limestone, 50 feet of Compton Conglomerate, followed by about 700 feet of paralic sands and grits of the Knight Group.

Below 1040 feet the well intersected 3945 feet of Merino Group mudstones, siltstones and sandstones. The Upper Member of the Runnymede Formation of Albian to (?) Cenomanian age was 2340 feet thick and of marine origin in at least the lower 800 feet, between 2586 and 3380 feet; the lower non-marine member of the Runnymede Formation (? Aptian) was represented between 3380 and 4200 feet. A slight angular unconformity is interpreted at about 4200 feet, below which the well is considered to have entered non-marine mudstones and sandstones of the Mocamboro Member - (?) Upper Jurassic. The well was still in this Member when drilling ceased.

INTRODUCTION

Penola No. 1 Well was drilled between 7th February and 18th April, 1961 by Oil Development N.L. under a "farm-out" agreement with General Exploration Company of Australia Ltd. The well is sited on Section 500, Hundred of Penola, 3 1/4 miles north-north-east of Penola.

Cuttings were taken every 5 feet and cores every 200 feet below 1200 feet.

This report presents lithological and stratigraphic data based on identification of foraminifera and of some plant megaspores and leaves.

STRATIGRAPHY

SUMMARY

Penola No. 1 Well intersected the following stratigraphic units:

	Depth (feet)
PLEISTOCENE	
Calcareous sandstone	0- 35

*Publication authorized by the Director of Mines, Department of Mines, South Australia.

TERTIARY		
Gambier Limestone	Oligocene	35- 250
Compton Conglomerate	Oligocene	250- 300
Knight Group sands	Eocene	?300-1040
CRETACEOUS		
Merino Group: Runnymede Formation		
Upper Member	Albian-Cenomanian	1040-3380
Lower Member	? Aptian	3380-4200
? UPPER JURASSIC		
Mocamboro Member		4200-4985

The Tertiary sediments were all of marine or paralic origin. With the exception of a section between 2586 and 3180 feet in the Upper Member of the Runnymede Formation, the Cretaceous and Upper Jurassic did not contain any marine micro-fossils and are considered to be of non-marine origin.

PLEISTOCENE

Above 35 feet the well intersected yellow-brown calcareous sandstone with coarse, rounded to fine angular quartz grains, calcite and limonitic clay. The foraminiferal assemblage consists of "Rotalia" beccarii and species of Elphidium, indicating deposition in shallow waters of low salinity.

TERTIARY

Gambier Limestone

Between 35 and 250 feet the well passed through typical Gambier Limestone, bryozoal limestone with abundant Victoriella conoidea (= plecte Chapman) and an associated foraminiferal assemblage with Globigerina bulloides, Globigerina woodi, Globigerina venezuelana, Stomatorbina concentrica and Eponides repandus. The Gambier Limestone is regarded as of Oligocene age at this level.

Compton Conglomerate

Between 250 and 300 feet cuttings contain bryozoal limestone with limonite pellets, passing into brown ferruginous sandstone with abundant Cassidulina subglobosa associated with Sherbornina atkinsoni, Cibicides brevoralis, Anomalinoides procolligera and Bolivinopsis crespinae. This interval is regarded as equivalent to the Compton Conglomerate of Oligocene age. Because of lack of samples between 300 and 505 feet due to lost circulation, the base of the formation cannot be determined accurately.

Knight Group sands

From 505 feet to 1040 feet the well intersected grey-white friable fine to medium pyritic and carbonaceous sands of the Knight Group. The sands are clayey at 905 feet, where one pyritized test of Cyclammina occurred, and become gritty towards the base. They are of paralic origin and of middle to upper Eocene age.

CRETACEOUS MERINO GROUP

Runnymede Formation: Upper Member

There is a marked discontinuity at 1040 feet where the well passed abruptly from the Eocene to Cretaceous arkosic sandstones and siltstones of the Merino Group. The youngest of these belonging to the Upper Member of the Runnymede Formation, consist of greenish-grey fine sandstones and sandy siltstones with quartz, angular feldspar, pyrite, biotite, chlorite, and, between 1040 and 1400 feet, abundant yellow tourmaline (variety dravite) identified by the Petrology Section, Australian Mineral Development Laboratories (Report A.M.D.L. P45/61).

Palaeontologically, the formation is distinguished by abundant spores of the water fern Azolla which first appears at 1155 feet and is still abundant in Core No. 12, 3363-3373 feet. These megaspores are common in the Albian-Cenomanian of the Great Artesian Basin and were present in Loxton, "Company" (Ludbrook, 1961, p. 11) and Comaum No. 2 Bores. Although they are usually restricted to the Albian-Cenomanian, they occur rarely also in the Aptian, evidently where conditions for their occurrence and deposition were favourable.

They occur commonly in Great Artesian Basin sediments containing foraminifera and are therefore regarded as being washed down by rivers and not necessarily indicators of fresh water sedimentation.

The lithological character of the Upper Member of the Runnymede Formation as represented in Comaum and Penola wells is very similar to that of the lower part of the Winton Formation of the Great Artesian Basin. This, together with the presence of Azolla and other megaspores including an iridescent form which characterizes the base of the Winton and upper part of the Tambo Formation, suggests that the Upper Member of the Runnymede Formation is of Albian-Cenomanian age. The member also contains angiosperms (Kenley, 1954, pp. 7, 8).

Apart from occasional fish fragments, not necessarily of marine origin, no positive evidence of marine deposition was obtained in the upper part of the formation, but between 2586 feet (Core No. 8) and 3195 feet (in cuttings) occasional foraminifera are present with fish teeth and hollow teeth of either amphibia or reptiles. The foraminifera consist of two poorly developed fragments of Hyperammina and a fairly well developed specimen of Ammobaculites fisheri, which occurs throughout the Albian and Aptian of the Great Artesian Basin.

The Upper Member of the Runnymede Formation is therefore regarded as of partial or wholly marine origin in Penola No. 1 Well, deposition having taken place either in a trough into which water ferns growing on rivers and lagoons were swept, as indicated by their abundance at certain levels, or of partial lacustrine and marine origin dependent upon changes of sea-level and consequent isolation of salt bottom waters in lakes as described by Strøm (1961).

Runnymede Formation: Lower Member

Below 3380 feet the well intersected a sequence of grey-brown carbonaceous and calcareous mudstones with abundant plant material and thin coal seams interbedded with current bedded siltstones, micaceous siltstones and arkosic sandstones grading to grits towards the base of the formation.

The interval 3380–4200 feet is correlated with the lower part of the Runnymede Formation as described by Kenley (1954, p. 6). The age is tentatively determined as Aptian or Aptian - Neocomian.

? UPPER JURASSIC MOCAMBORO MEMBER

A slight angular unconformity is interpreted at 4200 feet where the well entered grey mudstones and siltstones with coalified plant remains, abundant fine biotite and muscovite and scattered coarse subrounded quartz. Crossbedding and small slump structures are common. Taeniopteris spatulata is abundant with Thinnfeldia sp. Although the range of the plant assemblage is somewhat uncertain it was interpreted by Medwell (1954, p. 22) as of probable Upper Jurassic age.

If the unconformity has been correctly determined, it corresponds to the disconformity between the Runnymede Formation and the Mocamboro Member exposed at Killara Bluff (Kenley, 1954, p. 6).

DETAILS OF THE SAMPLES

Core	Cuttings (feet)	Lithology
	15- 35	Yellow-brown calcareous sandstone with coarse, rounded to fine angular quartz grains, calcite, limonitic clay.
	35- 250	Cream grading to grey-white bryozoal limestone, friable, with Victoriella conoidea (= plecte).
	250- 295	Brown bryozoal limestone and ferruginized sandstone with limonite pellets, polished quartz grains coated with limonite.
	295- 300	Light brown friable ferruginous sandstone with brown subangular quartz grains coated with limonite, limonite pellets, some glauconite.
	300- 505	No samples.
	505- 735	Grey-buff white gritty sand, medium to very coarse, with angular to subangular quartz grains of both clear, smoky and grey quartz, some pyrite.
	735- 800	Light brownish-grey medium to coarse sand with carbonaceous matter.
	800- 820	Fine buff sand with muscovite, pyrite.
	820- 905	Grey coarse quartz sand, poorly sorted, with fine and coarse subangular quartz grains, pyrite, pyritized wood, carbonaceous matter. Some quartz pebbles to grit size.
	905- 910	Brown clayey pyritic quartz sand, unsorted, with fine to coarse mostly subrounded to subangular grains of clear and milky quartz, pyrite, muscovite, plant remains, one pyritized test of Cyclammina.

Core	Cuttings (feet)	Lithology
	910-1040	Light grey-brown silty pyritic sand with mostly coarse angular to subangular quartz, pyrite, pyritized wood fragments.
	1040-1115	Green-grey fine feldspathic sandy siltstone with abundant feldspar, fine angular quartz, abundant pyrite, green-grey grains, brown mica, carbonized plant fragments, abundant yellow tourmaline (dravite). Megaspores present.
	1115-1130	Green-grey fine feldspathic silty sandstone with minerals as above.
	1130-1200	Green-grey fine sandy siltstone grading to silty sandstone with angular feldspar, quartz, grey-green grains, abundant pyrite, yellow tourmaline, mica, carbonized and pyritized wood fragments.
1	1200-1210	Recovered 30". Green-grey interbedded siltstone and argillaceous sandstone with fine angular quartz, feldspar, abundant grey grains, pyrite, carbonaceous matter, calcite, occasional glauconite grains. Azolla present.
	1210-1305	Greenish-grey siltstone and fine sandstone with fine angular quartz, feldspar, green-grey grains, carbonaceous matter, pyrite, biotite, chlorite, yellow tourmaline, pyritized wood. Megaspores present, Azolla 1290-1295.
	1305-1410	Green-grey feldspathic siltstone and argillaceous sandstone with medium angular quartz, feldspar, green-grey grains, yellow tourmaline, calcite, carbonaceous matter, abundant pyrite, siderite, biotite, chlorite.
2	1410-1418	Recovered 24". Greenish-grey siltstone with fine angular quartz, feldspar, green-grey mineral grains, biotite, muscovite, chlorite, carbonaceous matter, pyrite.
	1418-1610	Greenish-grey siltstone as Core No. 2. Azolla common at 1490-1500. Pyritized wood at 1425-1430, pyritized shell fragment at 1510-1515, iridescent spores 1410-1415.
3	1610-1620	Recovered 30". Green-grey micaceous siltstone with fine angular quartz, muscovite, brown mica, green-grey grains, plant fragments.
	1620-1805	Green-grey siltstone with abundant medium angular quartz, green-grey grains, chlorite, pyrite, plant fragments, biotite, tourmaline, feldspar. Small spine at 1730-1735.
4	1805-1815	Recovered 24". Green-grey silty mudstone with fine angular quartz grains, feldspar, chlorite, green-grey clay minerals, brown mica.

Core	Cuttings (feet)	Lithology
	1815-2000	Green-grey mudstone with fine angular quartz, feldspar, green and grey quartz grains, plant fragments, pyrite, siderite.
5	2010-2020	Recovered 22". Grey mudstone with fine angular quartz, feldspar, grey and green clay mineral grains, muscovite, brown biotite, few plant remains, pyrite.
	2020-2195	Mudstone, micaceous, as Core No. 5.
6	2200-2210	Recovered 4 feet 2 inches. Top 2 feet light green-grey carbonaceous siltstone with angular fine quartz and feldspar, slightly calcareous, abundant chlorite, biotite. Bottom 2 feet light grey slightly carbonaceous mudstone with feldspar, mica, green and grey grains, chlorite.
	2210-2380	Mudstone as Core No. 6.
7	2380-2390	Recovered 34". Green-grey siltstone with feldspar, angular quartz, green and grey grains, chlorite, biotite, plant fragments.
	2395-2586	Green-grey calcareous mudstone, siltstone and fine sandstone with fine angular quartz, feldspar, brown clay material, pyrite, calcite cement, dolomite. Small spine at 2490-2495.
8	2586-2596	Recovered 7 feet. 8" from top. Greenish-grey arkosic siltstone with plant fragments, fine angular quartz grains, feldspar, abundant mica, green-grey grains. 46" from top. Grey carbonaceous mudstone, with fishtooth. 70" from top. Carbonaceous and somewhat pyritic mudstone with zircon. Azolla present.
	2600-2645	Green-grey mudstone with fine angular quartz grains, dolomite, plant fragments, feldspar, biotite, pyrite. Fragments of feldspathic sandstone 2625-2640. Carbonized megaspores of Azolla 2605-2610.
	2645-2655	Coal, with well preserved Azolla and other megaspores.
	2655-2770	Green-grey mudstone with fine angular quartz grains, feldspar, grey-green grains, dolomite, pyrite, chlorite, biotite, muscovite. Abundant plant remains and coal material. One Hyperammina at 2735-2740.
	2770-2790	Mudstone and coal.
9	2790-2798	Recovered 4 feet. Grey sandy mudstone with abundant megaspores. Core very broken and regarded as unreliable.
	2795-2820	Grey-brown mudstone and coal, with pyrite, medium angular quartz, chlorite, feldspar.

Core	Cuttings (feet)	Lithology
	2820-2885	Contaminated with sand and cement.
	2885-2990	Green-grey siltstone with fine angular quartz, feldspar, green and grey grains, calcite, some coal and mudstone.
10	2990-3000	Recovered 5 feet 6 inches. Green-grey carbonaceous mudstone and very fine silty sandstone with fine angular quartz and feldspar grains, abundant brown mica, abundant plant remains, calcite, chlorite. Megaspores including Azolla present.
	3000-3060	Brownish-grey carbonaceous mudstone and siltstone with abundant carbonized plant fragments, fine muscovite.
	3060-3080	Brownish-grey feldspathic compact sandstone wtih some mudstone; medium angular quartz grains, micas, abundant plant remains, ferruginous minerals, feldspar, green-grey grains, rare pyrite.
	3080-3180	Grey calcareous mudstone with some sandstone. Medium angular quartz grains, green and green-grey grains, pyrite, carbonaceous matter, biotite, dolomite globules, chlorite. Abundant carbonized Azolla.
11	3180-3190	Recovered 5 feet. Greenish-grey calcareous fine sandstone and mudstone with fine angular quartz, feldspar, mica, plant remains, chlorite, calcite, green-grey grains. Reptilian or amphibian tooth present with Azolla. Ammobaculites fisheri present in cuttings 3185-3190.
	3190-3363	Mudstone and sandstone as above. Hyperammina present 3190-3195. Abundant coaly matter at 3210-3220.
12	3363-3373	Recovered 18". Greenish-grey carbonaceous arkosic siltstone with small mud pellets; abundant plant remains, feldspar, fine angular quartz grains, brown biotite, coaly material, green-grey grains, chlorite.
	3380-3514	Grey carbonaceous and calcareous mudstone with angular quartz, feldspar, mica, plant remains, pyrite, calcite. Plant megaspores, fish plate 3495-3500.
13	3514-3524	Recovered 6 feet. Medium grey mudstone with scattered carbonized plant fragments. Much very fine clay material, fine mica, rounded aggregates of white clay mineral, rare pyrite, chlorite.
	3524-3715	Grey mudstone with fine angular quartz, feldspar, clay material, mica, carbonized plant fragments, green-grey grains.

Core	Cuttings (feet)	Lithology
14	3715-3729	Recovered 7 feet. Grey mudstone interbedded with sandstone and siltstone, current bedded in part, mica flakes, chlorite, biotite, pale green-grey grains; scattered medium quartz grains. Abundant plant fragments in places, elsewhere scattered in matrix.
	3729-3917	Light grey carbonaceous arkosic sandstone interbedded with mudstone and siltstone as Core No. 14.
15	3917-3928	Recovered 2 feet 2 inches. Grey irregularly laminated and current bedded calcareous siltstone with abundant carbonized plant fragments; muscovite and biotite.
	3928-3957	Grey mudstone, sandstone and siltstone as above with traces of coal material.
16	3957-3962	No recovery.
	3962-4082	Light grey coarse arkosic sandstone with coarse angular quartz grains, coal matter, pyrite, feldspar; interbedded with mudstone and micaceous siltstone.
17	4082-4092	Recovered 7' 8". Grey siltstone both sandy and flaky, very micaceous in part with medium ill-sorted angular quartz grains, kaolinitic matter, coal fragments, garnet.
	4092-4200	Grey mudstone with coarse quartz grains and carbonaceous material.
	4200-4270	Grey micaceous siltstone and mudstone with coarse subangular to subrounded quartz grains scattered throughout a brownish-grey matrix with abundant fine plant remains and mica.
18	4270-4280	Recovered 4" - no samples received.
	4270-4390	Grey micaceous siltstone and mudstone as 4200-4270.
19	4390-4400	Recovered 10 feet. Grey mudstone crowded with coalified plant remains, crossbedded, with small slump structures, fine quartz grains, abundant fine mica, scattered coarse subrounded quartz. Abundant Taeniopteris spatulata leaves and stems. Apparent dip 15^{o}.
	4400-4600	Brownish-grey feldspathic siltstone, mudstone and some sandstone with abundant plant remains, pink garnet.
20	4600-4619	Recovered 19 feet. Grey carbonaceous siltstone and mudstone interbedded with light grey sandstone with silty patches; abundant biotite and muscovite; small slump structures and cross bedding. Apparent dip about 18^{o} to 25^{o}. Abundant Taeniopteris spatulata, Thinnfeldia and other carbonized plant remains.

Core	Cuttings (feet)	Lithology
	4619–4766	Mudstone, siltstone, and sandstone as above.
21	4766–4776	Recovered 6 feet. Light grey current bedded arkosic sandstone interbedded with grey mudstone and siltstone with abundant carbonized plant remains; micaceous siltstone partings in sandstone which is compact with kaolinitic cement.
	4776–4985	Grey mudstone, siltstone, and sandstone as above, coal band at 4895–4900.

Well abandoned.

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Fig.3

OIL DEVELOPMENT N.L.

PENOLA No.1 WELL —

MICROPALAEONTOLOGICAL LOG

	PLEISTOCENE	OLIGOCENE					EOCENE	CRETACEOUS																																																
		GAMBIER LIMESTONE			COMPTON CONGLOMERATE		KNIGHT GROUP	MERINO GROUP (RUNNYMEDE FORMATION)																																																
								UPPER MEMBER																																												LOWER MEMBER				
CORE											1				2																	8									9			10			11					12		13		17	
CUTTINGS EXAMINED (Depth in feet)	15-20	95-100	110-115	215-220	275-280	295-300	905-910	1100-1105	1140-1145	1155-1160	1200-1210	1250-1255	1290-1295	1330-1335	1410-1418	1410-1415	1425-1430	1455-1460	1485-1490	1490-1495	1495-1500	1510-1515	1535-1540	1620-1625	1710-1715	1730-1735	1755-1760	1800-1805	1830-1835	2395-2400	2490-2495	2586-2596	2605-2610	2630-2635	2635-2640	2640-2645	2645-2650	2650-2655	2695-2700	2735-2740	2790-2798	2885-2890	2895-2900	2990-3000	3060-3065	3070-3125	3180-3190	3185-3190	3190-3195	3195-3200	3200-3363	3363-3373	3495-3520	3514-3524	3845-3850	4082-4092	
CIBICIDES REFULGENS	V																																																								
ELPHIDIUM ADVENUM	F																																																								
ELPHIDIUM CRISPUM	R																																																								
ELPHIDIUM MACELLUM	R																																																								
ELPHIDIONONION SIMPLEX	V																																																								
NOTOROTALIA CLATHRATA	V																																																								
"ROTALIA" BECCARII	F																																																								
TEXTULARIA KERIMBAENSIS	-	R																																																						
TEXTULARIA PSEUDOGRAMEN	-	V	R	V	V																																																				
GAUDRYINA (PSEUDOGAUDRYINA) CRESPINAE	-	R																																																						
KARRERIELLA CF. BRADYI	-	V																																																						
GUTTULINA IRREGULARIS	-	V	V	V	-	V																																																			
ROBULUS SP.	-	V																																																						
PULLENIA BULLOIDES	-	V																																																						
EPONIDES REPANDUS	-	V	F	V																																																				
CIBICIDES LOBATULUS	-	V	-	V	-	R																																																		
CIBICIDES VORTEX	-	R																																																						
GLOBIGERINA BULLOIDES	-	C	F	-	R	C																																																		
GLOBIGERINA WOODI	-	F	V	-	V	F																																																		
STOMATORBINA CONCENTRICA	-	V	V	V																																																				
CARPENTERIA ROTALIFORMIS	-	V	V	V																																																				
VICTORIELLA CONOIDEA	-	R	C	V																																																				
NOTOROTALIA HOWCHINI	-	V																																																						
GLOBULINA GIBBA			R	V																																																					
PSEUDOPOLYMORPHINA TASMANICA			V																																																						
GYROIDINA SP. A			V																																																						
GLOBIGERINA VENEZUELANA			V																																																						
DOROTHIA SP.				V																																																					
NODOSARIA SP.				V																																																					
GUTTULINA PROBLEMA				V																																																					
TRIFARINA BRADYI				V																																																					
HERONALLENIA PARRI				V																																																					
BOLIVINOPSIS CRESPINAE					V																																																			
CASSIDULINA SUBGLOBOSA					A	A																																																		
CIBICIDES BREVORALIS					R	F																																																		
ANOMALINA SUBGLABRATA					V	V																																																		
ANOMALINOIDES PROCOLLIGERA					V																																																			
ELPHIDIUM CRESPINAE					V	V																																																		
SHERBORNINA ATKINSONI					V																																																			
VAGINULINOPSIS SP.						V																																																		
CIBICIDES PERFORATUS						V																																																		
CYCLAMMINA SP.							V																																																	
HYPERAMMINA SP.																																								V	-	-	-	-	-	-	-	-	V								
AMMOBACULITES FISHERI																																																V									
FISH FRAGMENTS																		V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	V				
FISH TEETH																									V	-	-	-	-	-	-	V																									
SPINES (?FISH)																												V	-	-	V																										
TEETH (AMPHIBIAN OR REPTILE)																																																V	-	V							
SHELL FRAGMENT (PYRITIZED)																						V																																			
MEGASPORES (UNIDENTIFIED)								V	V	-	V	V	-	-	V	V	-	-	F	V	V	-	-	V	V	-	-	-	-	V	-	-	-	-	-	-	-	V	-	-	V	V	-	R	-	-	V	-	V	R	R	V	-	A	F	V	-
IRIDESCENT MEGASPORES																V	V																																								
AZOLLA MEGASPORES										V	V	-	V	V	-	-	-	-	F	C	F	V	V	-	-	-	V	R	V	-	-	C	R	V	V	V	V	-	V	-	A	-	V	F	V	A	F	F	F	F	F	C					
OOGONIA OF CHARACEAE																																										V																

Depth in feet	PLEISTOCENE	OLIGOCENE		EOCENE	CRETACEOUS (CENOMANIAN - ALBIAN)	APTIAN
		GAMBIER LIMESTONE	COMPTON CONGLOMERATE	KNIGHT GROUP	MERINO GROUP (RUNNYMEDE FORMATION)	
	0-35	35-250	250-300	505-1040	1040-3380	3380-4200

V .... VERY RARE ...... 1 - 2
R .... RARE .... 3 - 5
F .... FREQUENT .... 6 - 10
C .... COMMON .... 11 - 25
A .... ABUNDANT .... > 25

} SPECIMENS

SA DEPT. OF MINES

To accompany report by N.H. Ludbrook.

APPENDIX 3

A PALYNOLOGICAL REPORT ON O.D.N.L. PENOLA NO. 1 WELL, SOUTH AUSTRALIA

by

P.R. Evans, Bureau of Mineral Resources

This report outlines the results of a palynological study of core samples and the deepest cuttings from the Penola No. 1 Well, South Australia.

SUMMARY OF RESULTS

Where sufficient microfossils have been extracted, only Cretaceous sediments are recognized. Coring commenced at 1200 feet; no estimate of age for strata above that level is given. Unfortunately samples from Cores 1 - 7 (1200-2390 feet) either were barren or yielded no diagnostic spores. Core No. 8 (2586-2596 feet) contained abundant microspores and very rare micro-plankton; a Lower Cretaceous, (?) Albian age for this horizon is suggested and it gave the only hint of the presence of marine sediments in the well section. It is possible, however, from recent work on the Port Campbell wells in Victoria (Evans, 1961) that strata as young as the Cenomanian are represented. Cores 9 to 11 (2790-3190 feet) were virtually barren, but Cores 12 - 19 (3363-4400 feet) generally contained a high proportion of microspores, also of Cretaceous age, which differ from those of Core No. 8 in assemblage composition and which indicate that this interval is low in the Lower Cretaceous. Core No. 20 gave a moderate yield, considered to be Cretaceous in age, but Core No. 21 (4766-4776 feet) provided a low yield of microspores which suggested an age either very low in the Cretaceous or possibly very high in the Upper Jurassic. On the basis of previously defined criteria (Evans, 1963) for the Jurassic-Cretaceous boundary in eastern Australia, a Cretaceous age is preferred.

OBSERVATIONS

The distribution of the important species which may be compared with described forms is illustrated in the appended Table 1. A number of apparently new species has been observed, particularly from Core No. 12 downwards. However, their presence does not seem to affect any stratigraphic conclusions based on published types. The following characters of the distribution chart are considered to be of stratigraphic significance -

(a) The association of Callialasporites dampieri and Lycopodiumsporites circolumenus within Cores 19, 20 and 21 (4390-4776 feet) seems to distinguish an horizon towards the base of the Cretaceous if not in the Upper Jurassic. Neither species is present in abundance, but this association is typical of a basal zone in the lowest marine strata of the Great Artesian Basin (Evans, 1963). Cuttings from 4980-4985 feet contained an abundance of microspores which suggest a Cretaceous rather than Jurassic age. However, the presence of Dictyotosporites cf. complex and an increased abundance of Inaperturopollenites indicate even closer approach to the Jurassic-Cretaceous boundary. This problem is further aggravated by the apparent absence of Cicatricosisporites australiensis below Core No. 13 (3524 feet): this is a species which elsewhere regularly appears first at a level close to the base of the Cretaceous.

(b) Among a wealth of Cyathidites spp. and Lycopodiumsporites spp. between Cores 12 and 19 (3363–4400 feet) were found many specimens of Granulatisporites dailyi and Dictyotosporites speciosus. They are species which seem to be restricted in geographical distribution to South Australia and Victoria (Cookson & Dettmann, 1958) and which have not yet been found farther away than the southern margin of the Great Artesian Basin. There, however, they occur low in the marine sequence in probable equivalents of the Cretaceous Roma Formation. Neoraistrickia truncatus probably ranges no further than the base of the Tambo Formation. Although there is a very different environment existing in the Penola area to that of the marine Cretaceous of the Great Artesian Basin (by comparison of gross spore assemblages) it is thus considered that beds between Cores 12 and 15 were deposited mainly in Aptian and perhaps partly in Albian times.

(c) Core No. 8 (2586-2596 feet) yielded another assemblage that differs greatly from the lower one in that the previously major component of Cyathidites and Lycopodiumsporites is severely reduced in abundance and that forms such as Cingulatisporites euskirchensoides and Balmeisporites holodictyus are present. Although C. euskirchensoides ranges throughout the Lower Cretaceous and even into the Cenomanian, it is typical, with B. holodictyus, of the highest marine strata of the Great Artesian Basin and the overlying freshwater series (Winton Formation). On the same basis as before, an Albian age is suggested for this horizon. The presence of a few specimens of Micrhystridium sp. implies that a marine influence existed at the time, but the lack of any dinoflagellates cautions that the influence may not have been great.

(d) Lunatisporites limpidus in Core No. 8 and Granulatisporites micronodosus in Core No. 6 (2200-2210 feet) suggest that Permian or basal Triassic sediments were being eroded during Lower Cretaceous times. Reworked Palaeozoic spores are characteristic of the Upper Cretaceous and Eocene of South Australia and Victoria (Cookson, 1956), but the Lower Cretaceous beds of the Penola Well are the oldest Mesozoic of the area yet known to yield derived fossils of Palaeozoic age.

COMPARISON WITH NEIGHBOURING WELLS

The nearest bores to Penola on which palynological studies have been published were at Nelson and Comaum in Victoria and at Robe and Loxton in South Australia.

The Nelson Bore (Baker & Cookson, 1955) penetrated Tertiary and marine Upper Cretaceous sediments, the equivalents to which have not been identified at Penola. Baker and Cookson dated the bore only to a depth of 6233 feet, but samples which have been examined in the Bureau of Mineral Resources to a depth of 7296 feet (total depth of bore 7305 feet) contained a younger microflora than the Cretaceous in the Penola Well and it is thought that the Nelson Bore never completely penetrated the Upper Cretaceous.

Cookson and Dettmann (1958) examined five samples, covering the interval 1400–4300 feet, of the old bore at Robe (drilled by S.A. Oil Wells Co. to a depth of 4504 feet) the spores from which are directly comparable with those distributed through Penola No. 1. L. circolumenus, D. speciosus, G. dailyi, Ischyosporites scaberis and Cyclosporites hughesi were common to samples at 3860 feet and 4300 feet in the Robe bore, and are common to the Penola assemblages between Cores 12 and 19 (3363–4400 feet), particularly to that in Core No. 15 (3917-3928 feet). The presence of C. euskirchensoides at 1400 feet and 2630 feet and B. holodictyus at 1400 feet in the Robe Bore ally these horizons closely with Penola No. 1, Core No. 8 (2586-2596 feet).

Two samples from the Comaum Bore at 651 and 708 feet and samples from Loxton at 1410-1470 feet (Cookson & Dettmann, 1958) approach Penola No. 1, Core No. 8, in age.

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TABLE 1

SPECIES	CORE NUMBER (*)
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 19 20 21 A
Pityosporites grandis	+----------+--+-----+--+--+--+
Cyathidites australis	+----cf. +-+----------+--+-----+--+--+-----+
Inaperturopollenites sp.	+----------+--------+--+
Granulatisporites cf. micronodosus	+
Gleicheniidites circinidites	+
Microcachryidites antarcticus	+-+---------+---------+-----+--+--+
Araucariacites australis	+-+
Baculatisporites comaumensis	+---------+--+-----+--+--+--+--+
Classopollis torosus	+----------+--+--+--+
Cicatricosisporites australiensis	+---------+--+
Ginkocycadophytus nitidus	+---------+-----+-----+
Cingulatisporites euskirchensoides	+----------+
Balmeisporites holodictyus	+
Pilosisporites notensis	+
"Cirratriradites" sp.	+
Lunatisporites limpidus	+
Schizosporis reticulatus	+-----+--+----------+
Cyath. australis rimalis	+--+--+--+--+--+--+--+
Lycopodiumsporites austroclavatidites	+--+--+--+--+--+--+
Lycopodiumsporites spp.	+--+--+--+--+--+--+--+
Leptolepidites verrucatus	+--+--+--+--+--+-----+
Podocarpidites spp.	+--+-----+--+--+--+--+
Dictyotosporites speciosus	+--+--------+
Aequitriradites tilchaensis	+----------+
Sphagnumsporites australiensis	+
Concavisporites cf. juriensis	+
Minerisporites marginatus	+
Neoraistrickia truncatus	+--+--+-----+--+
Podocarpidites micropterus	+--+
Cyclosporites hughesi	+
Ischyosporites scaberis	+-----+-----cf.
Lycopodiumsporites cf. rosewoodensis	+-----+-----+
Callialasporites dampieri	+--+--+--+--+
Lycopodiumsporites circolumenus	+--+--+--+
Inaperturopollenites cf. limbatus	+
Cicatricosisporites cooksonii	+
Cingulatisporites cf. floridus	+
Dictyotosporites cf. complex	+
Micrhystridium sp.	+

TABLE 1. (Cont'd)

(*) Samples were taken from the following depths :

Core No.	1	1200 - 1210 feet;	6" - 11" from top,
"	2	1410 - 1418 " ;	
"	3	1610 - 1620 " ;	15" from top,
"	4	1805 - 1815 " ;	8" " "
"	5	2010 - 2020 " ;	top of core,
"	6	2200 - 2210 " ;	top 2 feet,
"	6	2200 - 2210 " ;	bottom 2 feet,
"	7	2380 - 2390 " ;	21" from top,
"	8	2586 - 2596 " ;	12" " "
"	9	2790 - 2798 " ;	2 feet from top,
"	10	2994'8" - 2995 " ;	
"	11	3180 - 3190 " ;	7 feet " "
"	12	3363 - 3373 " ;	top 1'6",
"	13	3514 - 3524 " ;	2'6" from top,
"	14	3715 - 3715'4" ;	
"	15	3917 - 3928 feet;	
"	19	4390 - 4400 " ;	
"	20	4618'8" - 4619 feet;	
"	21	4766 - 4776 " ;	5 feet from top,
Cuttings (A)		4980 - 4985 feet.	

APPENDIX 4

NOTES ON FOSSIL PLANT FRAGMENTS

Plant Fragments in Penola No. 1 Well, South Australia

by

Mary E. White, Bureau of Mineral Resources

Oil Development N.L. submitted cores from Penola No. 1 Well in South Australia for palynological examination. Core No. 19, from 4390-4400 feet, contains fragmentary plant impressions with a film of surface carbon and some carbonized wood fragments.

Two impressions of small portions of Taeniopteroid leaves are present. One shows 1.25 cm of lamina approximately 0.75 cm wide with a prominent midrib and parallel lateral veins at right angles to the midrib (approximately 20 laterals per cm). There is no indication of a marginal vein. This fragment is referable to Taeniopteris and is similar to T. spatulata and other species of Jurassic and Lower Cretaceous horizons.

The second fragment of lamina is 1 cm long and 0.25 cm wide. It has a prominent midrib and the secondary veins fork immediately they leave the midrib. There are approximately ten parallel laterals in the 1 cm length. There is no marginal vein. This fragment is also referable to Taeniopteris and resembles T. carruthersi Tenison Woods.

Taeniopteris leaves of both types described above occur in Jurassic and Lower Cretaceous horizons. No closer estimate of age can be made.

Examination of Core Sample from Penola No. 1 Well, South Australia

by

J. Douglas, Mines Department, Victoria*

Rock type:	Fine blue-grey sandstone with black carbonaceous plant impressions.
Locality:	Penola No. 1 Well, South Australia.
Depth:	2380-2390 feet.
Sender:	Oil Development N.L.
Date:	14.3.61.

Examination of Plant Impressions

Apart from fragmentary carbonaceous remains, the sole specimen worth examination was a wedge-shaped impression, apparently attached to a stem. Small pieces of cuticular material were isolated from this using Schultze's oxidizing solution, and these showed some characteristics of certain Mesozoic fern-like foliaged plants. Further identification could not be attempted because of lack of more specific knowledge of Victorian Mesozoic plant cuticles.

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* Publication authorized by the Secretary for Mines, Department of Mines, Victoria.

Palynological Examination

Core was crushed, and treated by the hydrofluoric acid Schultze's solution method, and the acid insoluble residue examined under a microscope.

A depauperate microflora including gymnosperm pollens, Cingulatisporites and Cyathidites sp. indicates affinities with Victorian and certain South Australian non-marine Mesozoic sediments. Insufficient microfossils have been isolated to attempt correlation with any particular area, but it appears that the sample would belong to the Lower Cretaceous age assigned by Cookson and Dettmann for this microflora.

Plant Impressions from Penola No. 1 Well

Preliminary Examination

by

J. Douglas, Mines Department, Victoria

	Core No. 15	Core No. 19
Locality:	Penola No. 1 Well	Penola No. 1 Well
Rock type:	Soft grey sandstone	Blue-grey mudstone
Depth:	3917-3928 feet	4392 feet
Sender:	Oil Development N.L.	Oil Development N.L.
Date:	7.4.61	11.4.61
Specimen Nos:	1-5	1-8

Both cores contained plant remains in the form of black carbonaceous leaf impressions.

Core No. 15

Specimen No. 1 This appears to represent three pinnules attached by the whole base on one side of a rachis and forming a narrow lamina. Venation is not visible. The fragmentary remains, correspond with the diagnosis of the pteridosperm Thinnfeldia pinnata Walkom. Some preliminary cuticular preparations (treatment by Schultze's Solution and manipulation) show delicate thin cuticle of sinuous walled rectangular cells arranged in rough rows. Although the cuticle of T. pinnata has not previously been described, Townrow (1957) regards this as a synonym of Dicroidium odontopteroides (Morris) Gothan, which also has sinuous walled cuticular. Further investigation of this cuticle may help solve the T. pinnata - D. odontopteroides relationship. Stomata are not present and average cell size is 48 x 26 u.

Specimen No. 2 This appears to be a small fragment of the spatulate leaf of Taeniopteris spatulata, Oldham and Morris. Venation is not preserved.

Specimens Nos 3 and 4 Unidentified stem fragments.

Speciment No. 5 This may represent a stem with attached leaf, but is very obscure.

Core No. 19

Specimens Nos 1, 2, 3 and 4 Several specimens are closely appressed on 6.5 mm diameter core and all appear to represent Taeniopteris spatulata. Although better preserved than Core No. 15 specimens (with nearly 6 mm of lamina present in one case and venation clearly visible) no cuticle has been obtained.

Specimen No. 5 This is obscure but specimens 6, 7, and 8 are probably Taeniopteris fragments.

Taeniopteris spatulata and Thinnfeldia pinnata have been described as part of a "Lower Jurassic" Victorian flora by Medwell (1954), and T. pinnata is known elsewhere only from the Jurassic.

Cookson and Dettmann have established on microfloral evidence a Lower Cretaceous age for Victorian beds with similar plant remains.

However, both species are probably members of floral assemblages in Victoria of several different Mesozoic stages and no reliable age determination within the Mesozoic can be established for the cores at this juncture.

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APPENDIX 5

REPORT ON GAS SAMPLE FROM O.D.N.L.

PENOLA NO. 1 WELL

by

R. Hare and Associates

Tabulated below is the analysis of a gas sample collected from circulating drilling mud at Penola No. 1 Well. The analysis was made by the Research and Testing Department of the Gas and Fuel Corporation of Victoria, by arrangement through the Chemical Laboratories of the Departments of Agriculture, Health and Mines, Victoria.

The sample was collected by Mr. L. W. Stach, assisted by Messrs. Cundill and Bollen (well-site geologists), on 25th April, 1961.

On 25th April, during cleaning-out of the hole preparatory to making a micro-log and caliper survey, the circulation of the drilling mud was suspended with the bit at about 4000 feet, while adjustments were being made to the mud pump. After the mud had been standing for a few minutes in the ditch, the surface of the mud became pitted from the occasional bursting of gas bubbles, but the quantity of gas coming from the mud was too small to obtain samples.

Prior to resuming circulation at about 4000 feet, and cleaning out below this depth, the mud hose of the agitator box belonging to the Wemco gas detector was fitted to the mud outlet above the shale-shaker to draw the circulating mud through the agitator box. When circulation was resumed, the mud flowed into the top of the agitator box and fell over a series of baffles which broke out the gas contained in the mud. As the interior of the agitator box is freely accessible to the outside air, the quantity of any hydrocarbon gas that might pass out of the mud would be greatly diluted by free air when drawn off from the outlet at the top of the agitator box. The hydrogen supply for the Wemco gas detector was exhausted at that time, so it was not possible to determine the presence of hydrocarbons with this apparatus.

Several minutes after circulation of the mud had been resumed, air and gas were drawn from the top outlet of the agitator box by using the vacuum pump in the gas detector. After running the pump for a few minutes to clear the tubing of free air, the mixture of free air and gas was collected under water in two clean bottles by displacement of water in the bottles. The bottles were then sealed with rubber corks, with some water retained as a seal between the collected air and gas mixture and the corks; the bottles were then maintained in an upright position with a double seal of cork and water until delivered for analysis.

The analysis proves conclusively the presence in the drilling mud of hydrocarbon gas, which could have been derived only from formations exposed at depth in the open hole. The quantity of hydrocarbon gases in the total sample, 0.03235 percent, is of the order of the amount of dilution that would be expected from the method used for collection. The methane fraction of the total hydrocarbon gases amounts to 98.92 percent; the remaining fractions comprising the higher hydrocarbons as listed, total only 1.08 percent.

Such small percentages of higher hydrocarbons are known to occur in coal-field gases, and other sources of natural methane gas that are not considered to be of petroliferous origin. Hydrocarbon gases associated with crude oil generally have a much greater percentage of the higher hydrocarbons than the present sample, and it is therefore doubtful whether the sample from Penola No. 1 can be classed as a "petroliferous natural gas". It would be more appropriately described as "hydrocarbon gas consisting dominantly of methane, associated with a small percentage of hydrocarbons".

Report on Sample No. 417/61

by

John C. Kennedy, Mines Department, Victoria.

Sample	:	Bore-hole Gas
Locality	:	Penola
Sender	:	R. Hare and Associates, 20 Collins Street, MELBOURNE.

A sample of bore-hole gas, resulting from oil-drilling operations at Penola was received for qualitative and quantitative (if possible) analysis.

The gas was collected after issuing from drilling mud at the Oil Development N.L. Penola No. 1 Well. The sample of gas was perforce diluted very considerably by air and in this instance the analysis was carried out by the Research and Testing Department of the Gas and Fuel Corporation of Victoria.

Results:

	Percent
Methane	0.032
Ethane	0.0001
Ethylene	0.0001
Propane	0.00004
Propylene	0.00002
Isobutane	0.00002
n-Butane	0.00007

Higher hydrocarbons were probably present but were not determined.

APPENDIX 6

SOXHLET EXTRACTION TEST FOR TRACES OF OIL IN A SEDIMENT FROM PENOLA NO. 1 WELL, SOUTH AUSTRALIA

by

G. Baker and A.W. Hounslow, C.S.I.R.O., Melbourne

A core sample of sediment from 2380 to 2390 feet in the Penola No. 1 Well, South Australia, has been submitted on behalf of R. Hare and Associates for testing the presence of small traces of oil. The size of the core sample submitted was 2 1/2 inches by 1 3/4 inches.

Examination of Sediment

Hand lens inspection reveals that the sediment is a fine-grained, sandy, micaceous siltstone with occasional partially coalified fragments of vegetable matter measuring up to 25 mm long by 2 mm thick and ranging down to microscopic flecks. The specimen grades at one end into a pellet siltstone in which the pellets are up to 3 mm across and in which there are larger flakes of muscovite up to approximately 1 mm in size and rare flakes of a "bronzy" mica that are partially altered biotite.

An ammonium nitro-molybdate test on brownish-grey portions of the pellet siltstone was distinctly positive, indicating the presence of small amounts of phosphate. Weak, local effervescence with cold 1:1 HCl and stronger local effervescence with hot 1:1 HCl indicate the presence of a little $CaCO_3$ and of other rather less readily soluble carbonates in the matrix of the siltstone.

A thin section of the rock revealed a number of quartz grains ranging in size from under 0.01 mm up to approximately 0.5 mm. The larger of these are subrounded to rounded, the smaller are mostly angular. Also present are occasional angular cleavage fragments of altered orthoclase feldspars up to 0.5 mm by 0.2 mm in size, flakes of muscovite, less common flakes of partially altered and chloritized biotite, and rare accessory minerals including euhedral zircon. These are set in an abundant greenish-brown and brown, silty matrix containing carbonaceous matter and occasional plant spores, including trilete microspores.

An examination of the sediment for microfossils by Dr Isabel C. Cookson of the Botany Department, University of Melbourne, revealed an assemblage of microspores of Lower Cretaceous age. No marine microplankton were detected, and the microfloral assemblage includes comparable species to those described from sediments (i) at 329 feet in the Dergholm No. 2 Bore, Victoria, approximately 25 miles east of Penola, (ii) at 1079 feet to 1102 feet in the Birregurra No. 1 Bore, Victoria, and (iii) at 1400 feet, 1780 feet, 2325 feet and 2630 feet in the Robe Bore, South Australia.

Soxhlet Extraction Test

The sample was crushed to half-inch size fragments and hand-picked to eliminate as much as possible of the carbonaceous fragments. A number of flecks of carbonaceous

matter, however, could not be avoided. Proportions of the pellet siltstone were included with the hand-picked sample selected for testing in the Soxhlet apparatus. Approximately one half of the sample submitted was pulverized to minus 100 mesh (B.S.S.) and fifty grams were placed in an extraction thimble and subjected to three hours cycling in the Soxhlet extraction apparatus, using 150 ml of A.R. carbon tetrachloride; this was equivalent to approximately 50 cycles.

The bulk of the carbon tetrachloride was then removed by distillation. After cooling, the remainder (about 30 ml) which contained the extracted substances, was transferred to a 100 ml beaker, covered by a raised watch glass, and placed on a boiling water bath until the volume was reduced to approximately 3 ml. This solution was then transferred to a weighed 5 ml beaker, using a little distilled carbon tetrachloride, covered by a large beaker, and the solvent allowed to evaporate at room temperature over a period of three days. Re-weighing at the end of this period revealed a residue of 9.2 mgm. As the weight of residue from 150 ml of the carbon tetrachloride was previously found to be 2.9 mgm (cf. Mineragraphic Report No. 828), the percentage by weight of soluble substances extracted from the sediment was thus 0.013%.

Residue Obtained

The residue obtained by the Soxhlet extraction test yielded an aromatic odour. Under a Mineralight ultraviolet lamp it gave a strong fluorescent response in distinctly yellow fluorescent colours. Residue from the carbon tetrachloride itself did not reveal these properties.

The residue from the sediment was an oily fluid with greasy characteristics, containing substantial amounts of a crystalline fraction. Inspection under the binocular microscope with fluorescent lighting, revealed that the crystalline fraction was more strongly fluorescent than the oily fluid.

Under the petrological microscope, a smear of the residue revealed a very pale yellow-coloured oily liquid containing abundant colourless, strongly birefringent crystals with brilliant first order interference colours, straight extinction, and a refractive index higher than the oily fluid. The identity of these crystals was not established in view of the smallness of the residue extracted from the sediment and insufficient of the crystals for further testing.

Subsequent to examination, the residue was redissolved in 0.5 ml carbon tetrachloride; this yielded a pale yellow solution which was distinctly greenish in ultraviolet light.

FURTHER SEDIMENTS FROM PENOLA NO. 1 WELL, SOUTH AUSTRALIA

Four additional core samples of sediments from the Penola No. 1 Well have been submitted on behalf of R. Hare and Associates. Three are fine-grained sediments for which it was desired to test for the presence of small traces of oil. The fourth is a coarse-grained sediment submitted for determination of its characteristics.

The specimens were cored from O.D.N.L. Penola No. 1 Well at:

(1) 3514 ft to 3524 ft.)
(2) 3715 ft to 3729 ft.) - fine-grained sediments
(3) 4082 ft to 4092 ft.)

(4) 4082 ft to 4092 ft. - coarse-grained sediment

The samples examined were from:

(1) 1 foot above the bottom of the recovered core interval,

(2) 1 foot below the top of the recovered core interval,

(3) 3 feet below the top of the recovered core interval,

(4) the top of the core interval (1" of core material).

Soxhlet Extraction Tests

Soxhlet extraction tests were conducted on samples (1) to (3). One of the sediments (3514 ft to 3524 ft) contained a little fine-grained pyrite (authigenic), and a few ovoid pellets of oolitic dimensions (1.0 mm by 0.5 mm in size). Each sample, which was dense in texture and very fine-grained, was pulverised to minus 100 mesh (B.S.S.) to yield medium grey coloured powders in part having a faint greenish tinge. Fifty grams of each powder were placed in an extraction thimble and subjected to three hours cycling in the Soxhlet extraction apparatus, using 150 ml of A.R. carbon tetrachloride; this was equivalent to 50 cycles.

Distillation and evaporation of the extract solutions left minute amounts of oily fluids which gave a distinct yellow fluorescent response under a Mineralight lamp, and had a faintly aromatic odour. On redissolving the oily residue in 0.5 ml of carbon tetrachloride, a pale yellow solution resulted which was strongly greenish in fluorescent light.

The residues from Soxhlet extraction were very small for each sample, the proportions being :

		Percent residue
No. 1	-	0.008
No. 2	-	0.008
No. 3	-	0.009

Examination of coarser-grained sediment

The coarser-grained, gritty sediment from the top of the core interval recovered between 4082 and 4092 ft has been examined in the hand specimen and in thin section under the petrological microscope. The portion of the core submitted is only an inch thick, but it reveals a contact between a finer-grained pale greenish-grey sediment and coarser-grained rock. Occasional quartz grains up to 2 mm across and runs of carbonized plant fragments up to 2 mm x 1 mm in size occur in the finer-grained parts of the sediment. The coarser-grained portion of the rock has the texture and mineral composition of granite. Inasmuch as (i) finer-grained sediments occur above and below the coarser-grained granitic rock, (ii) there is no evidence of the intrusive character of the granitic rock, and (iii) the granitic rock appears weathered on the outside, with constituents of the finer-grained sediment penetrating along fractures, it is therefore concluded that the granitic rock is part of a small pebble.

In the hand specimen, the granitic parts reveal an average grain size of the quartz and feldspar of from 2 to 3 mm, with sparse smaller grains of pink garnet up to 0.5 mm across and a few flakes of biotite up to 1 mm long. A few of the feldspar crystals

are up to 8 mm across, and the quartz crystals range up to 6 mm across, while dense material along some grain boundaries and infilling interstices effervesces readily in cold 1:1 HCl and is calcite. This cementing medium has penetrated inwards along cracks from the weathered surface of the granitic pebble.

Thin section inspection of the granitic part of the rock reveals quartz, feldspar, biotite, chlorite, a little zircon and pale pink garnet, and occasional grains of opaque oxides. Some of the larger grains are revealed to be composite, consisting of intergrown quartz and feldspar. Occasional micrographic intergrowths occur between the quartz and feldspar in places. The feldspar is represented by flesh-coloured microcline, microcline-microperthite and oligoclase, and is little chemically altered by weathering. The calcite infilling interstices and following grain boundaries around the fractured outer surface of the granitic pebble, is in places accompanied by cryptocrystalline (chalcedonic) silica.

The finer-grained sediment contains a few of the coarser grains from the adjacent granitic rock, runs of carbonized plant remains, a little fine-grained pyrite and occasional pellets of a mineral resembling glauconite; sometimes these pellets are enveloped by calcite. In places chalcedonic silica appears in the matrix.

Conclusions

The finer-grained sediments subjected to Soxhlet extraction techniques yielded only very minor amounts of oily fluids.

The coarser-grained sediment examined petrologically is evidently a shallow-water, near-shore deposit laid down under probably marine or estuarine conditions. Calcareous and chalcedonic cementing media were developed in the relatively early stages of diagenesis, infilling fractures on the surface of an incorporated pebble of granitic rock and recementing together some of the looser granitic detrital grains adjacent to the firmer portions of the weathered pebble.

APPENDIX 7

FORMATION TEST REPORTS

by

J. Cundill and P.W. Bollen, R. Hare and Associates.

TEST NO. 1

Date:	March, 17/61
Well:	Penola No. 1
Formation Test:	No: 1 (open hole)
Interval tested:	3156 - 3190 feet
Formation tested:	Lower Cretaceous
Hole size:	5 5/8"
Packer set at:	3156 feet
Fluid cushion:	Nil
Pressure Recorders:	Nil
Choke size:	5/8"
Trip-Disc valve at:	3149 feet
Total depth:	3190 feet

RESULTS

Weight to set packer:	22,000 lb.
Initial shut in (period):	Nil
Valve open (period):	4 mins
Final shut in (period):	Nil
Blow:	Fair initial puff, strong blow when packer failed
Recovery:	1400 feet drilling mud
Initial hydrostatic pressure:	N/A
Initial shut-in pressure:	N/A
Initial flow pressure:	N/A
Final flow pressure:	N/A
Final shut-in pressure:	N/A
Weight to unseat packer:	30,000 lb.
Whether test mechanically successful:	No. Packer seat failed immediately on opening valve.

EQUIPMENT

Type of tester:	Johnston Type E.	(Single locking equalizing valve)	
Packer element size:	4 3/4"	Type: X	
Anchor length:	34 feet	Size: 3 1/2" O.D.	
Perforated length:	8 feet	Type: Perforated "N" Casing. Size of Perforation: 3/16"	
Tool size:	2 3/8" (3 1/8" O.D.)	Tool joint size:	2 3/8" F.E.D.P.
Reverse circulating valve:	None		

- - - - - - - - - - - -

TEST NO. 2

Date:	March, 18/61
Well:	Penola No. 1
Formation Test:	No: 2 (open hole)
Interval tested:	3179 - 3190 feet
Formation tested:	Lower Cretaceous
Hole size:	5 5/8"
Packer set at:	3179 feet
Fluid cushion:	Nil
Pressure Recorders:	Nil
Choke size:	5/8"
Trip-Disc valve at:	3172 feet
Total depth:	3190 feet

RESULTS

Weight to set packer:	22,000 lb.
Initial shut in (period):	Nil
Valve open (period):	4 mins
Final shut in (period):	Nil
Blow:	Fair initial puff, strong blow as packer failed
Recovery:	1470 feet drilling mud
Initial hydrostatic pressure:	N/A
Initial shut-in pressure:	N/A
Initial flow pressure:	N/A
Final flow pressure:	N/A
Final shut-in pressure:	N/A
Weight to unseat packer:	30,000 lb.
Whether test mechanically successful:	No. Packer seat failed immediately on opening valve.

EQUIPMENT

Type of tester: Johnston Type E. (Single locking equalizing valve)

Packer element size:	4 3/4"	Type:	X
Anchor length:	11 feet	Size:	3 1/2" O.D.
Perforated length:	8 feet	Type:	Perforated "N" Casing Size of Perforation: 3/16"
Tool size:	2 3/8" (3 1/8" O.D.)	Tool joint size:	2 3/8" F.E.D.P.

Reverse circulating valve: None.

- - - - - - - - - - - -

TEST NO. 3

Date:	April, 12/61
Well:	Penola No. 1
Formation Test:	No: 3 (open hole)
Interval tested:	4581 - 4619 feet
Formation tested:	Lower Cretaceous
Hole size:	5 5/8"
Packer set at:	4581 feet
Fluid cushion:	Nil
Pressure Recorders:	Nil
Choke size:	5/8"
Trip-Disc valve at:	4572 feet
Total depth:	4619 feet

RESULTS

Weight to set packer:	25,000 lb.
Initial shut in (period):	Nil
Valve open (period):	4 mins
Final shut in (period):	Nil
Blow:	Good initial puff, strong blow as packer failed
Recovery:	1780 feet of drilling mud
Initial hydrostatic pressure:	N/A
Initial shut-in pressure:	N/A
Initial flow pressure:	N/A
Final flow pressure:	N/A
Final shut-in pressure:	N/A
Weight to unseat packer:	35,000 lb.
Whether test mechanically successful:	No. Packer seat failed immediately on opening valve.

EQUIPMENT

Type of tester:	Johnston Type E. (Single locking equalizing valve)		
Packer element size:	4 3/4"	Type :	X
Anchor length:	38 feet	Size:	2 7/8"
Perforated length:	18 feet	Type:	Perforated Size of Perforation: 3/16" Acme D.P.
Tool size:	2 3/8" (3 1/8" O.D.)	Tool joint size:	2 3/8" F.E.D.P.

Reverse circulating valve: None.

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TEST NO. 4

Date:	May, 3/61
Well:	Penola No. 1
Formation Test:	No: 4 (open hole)
Interval tested:	3968 - 4175 feet
Formation tested:	Lower Cretaceous
Hole size:	5 5/8"
Packer set at:	3968 feet
Fluid cushion:	Nil
Pressure Recorders:	Nil
Choke size:	5/8"
Trip-Disc valve at:	3959 feet
Total depth:	4985 feet. Anchor set on cement plug at 4175 feet

RESULTS

Weight to set packer:	18,000 lb.
Initial shut in (period):	25 mins
Valve open (period):	2 mins
Final shut in (period):	Nil
Blow:	Strong blow as packer failed
Recovery:	800 feet of drilling mud
Initial hydrostatic pressure:	N/A
Initial shut-in pressure:	N/A
Initial flow pressure:	N/A
Final flow pressure:	N/A
Final shut-in pressure:	N/A
Weight to unseat packer:	20,000 lb.
Whether test mechanically successful:	No. Packer seat failed immediately on opening valve.

EQUIPMENT

Type of tester: Johnston Type E. (Single locking equalizing valve)
Packer element size: 4 3/4" Type: X
Anchor length: 207 feet Size: 2 7/8" (see note)
Perforated length: 18 feet Type: Perforated Size of Perforation: 3/16" Acme D.P.
Tool size: 2 3/8" (3 1/8" O.D.) Tool joint size: 2 3/8" F.E.D.P.
Reverse circulating valve: None

Note: Anchor pipe included 140 feet of cemented 2 3/8" drill pipe.

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TEST NO. 5

Date:	May, 4/61
Well:	Penola No. 1
Formation Test:	No: 5 (open hole)
Interval tested:	3959 - 4175 feet
Formation tested:	Lower Cretaceous
Hole size:	5 5/8"
Packer set at:	3959 feet
Fluid cushion:	Nil
Pressure Recorders:	Nil
Choke size:	5/8"
Trip-Disc valve at:	3950 feet
Total depth:	4985 feet. Anchor set on cement plug at 4175 feet

RESULTS

Weight to set packer:	18,000 lb.
Initial shut in (period):	24 mins
Valve open (period):	90 mins
Final shut in (period):	Nil
Blow:	Very weak air blow dying after 12 minutes
Recovery:	16 feet drilling mud
Initial hydrostatic pressure:	N/A
Initial shut-in pressure:	N/A
Initial flow pressure:	N/A
Final flow pressure:	N/A
Final shut-in pressure:	N/A
Weight to unseat packer:	25,000 lb.
Whether test mechanically successful:	Yes

EQUIPMENT

Type of tester:	Johnston Type E. (Single locking equalizing valve)	
Packer element size:	4 3/4"	Type: X
Anchor length:	216 feet	Size: 2 7/8" (see note)
Perforated length:	18 feet	Type: Perforated Size of Perforation: 3/16" Acme D.P.
Tool size:	2 3/8" (3 1/8" O.D.)	Tool joint size: 2 3/8" F.E.D.P.

Reverse circulating valve: None.

Note: Anchor pipe included 160 feet of cemented 2 3/8" drill pipe.

APPENDIX 8

ELECTRIC LOG REPORTS

O.D.N.L. PENOLA NO. 1 WELL

by

B. Boutan, Schlumberger Seaco Inc.

Interpretation logs run 5th March, 1961

(1) Logs run: Electrical log 2487 - 496 feet, run 1, scale 2" and 5"
Microlog-caliper, run 1, scale 2" and 5"

(2) Mud property:
Rm 2.45 at 75°F
Rmf 2.3 at 75°F
Rmc 2.6 at 75°F
Corrected for BHT (2487 ft)
Rm 1.8 at 104°F
Rmf 1.7 at 104°F
Rmc 1.6 at 104°F no mud log

(3) Top of logs: Fresh water formation from 1040 feet to casing shoe at 497 feet with a water of about 2.5 ohms m/m2. A water saturation of 100% and at the best intervals (507-804, 893-940) a porosity of about 25%.

Second part of the logs:

Numerous thin beds of more or less clean sandy formation; water being more salty with depth.

Everywhere the water saturation seems to be 100%

at 1340 ft we have water of resistivity Rw = .75 ohms m/m2
at 1680 ft " " " " " = .50 "
at 2020 ft " " " " " = .40 "
at 1679-1690 ft we seem to have a porosity of 27%-30%
Rw =.50 ohms m/m2 Sw = 100%

Other best intervals with a good proportion of shale or mudstone:

1337 - 1347 ft,	1465 - 1472 ft,	1530 - 1540 ft,
1560 - 1572 ft,	1715 - 1724 ft,	1913 - 1931 ft,
1933 - 1945 ft,	2105 - 2124 ft,	2158 - 2165 ft,

All these formations seem to have a fairly good permeability.

Interpretation logs run 25th - 27th April, 1961

(1) Logs run: Electrical log 4159-2487 feet, scale 1" and 5"
Microlog-caliper 3372-2487 feet, scale 1" and 5"

(2) Mud property for Electrical Log:

Rm 1.6 at 70°F
Rmf 1.5 at 72°F
Rmc 1.95 at 72°F

corrected at 4000 ft.

Rm 0.8 at 142°F
Rmf 0.75 at 142°F
Rmc 0.97 at 142°F

for Microlog-caliper

Rm 1.8 at 70°F
Rmf 2.4 at 55°F
Rmc 2.8 at 55°F

at 3300 ft.

Rm 1.15 at 122°F
Rmf 1.13 at 122°F
Rmc 1.35 at 122°F

(3) Remark: We seem to have a fairly high geothermal gradient
at 2486 ft we had 104°F
3372 ft " " 124°F
4159 ft " " 146°F

(4) Top of logs: 2487-3372 ft. Electrical log and microlog. Thin beds of more or less clean permeable formation, water being more salty with depth.

at 2700 ft and 2900 ft we have a water of resistivity Rw = .40 ohms m/m2
at 3200 ft " " " " " " " = .27 " "
at 2693-2697 ft and 2901-2903 ft we seem to have a porosity of 27%-30%

Rw = .40 ohms m/m2 Sw = 100%

at 3190-3200 ft we seem to have a porosity of 25%

Rw = .27 ohms m/m2 Sw = 100%

at 2654-2658 ft, 2854-2860 ft, 2922-2926 ft, 2933-2936 ft we seem to have the same kind of formation with more or less shale, mudstone or siltstone.

APPENDIX 9

WELL VELOCITY SURVEY REPORT

O.D.N.L. PENOLA NO. 1 WELL

by

S.A. Department of Mines*

A velocity survey was carried out in Penola No. 1 Well. For this survey the geophone was supplied by the Bureau of Mineral Resources and the cable by Schlumberger. The recording equipment used was the Texas Instruments 7000B owned by the South Australian Department of Mines.

For the well shoot a total of 15 shots were fired, located as shown in Figure 4. In addition, two reflection spreads were shot - shot points C1 and D1. Several shots were fired with the geophone at positions of particular interest specified by representatives of Oil Development N.L.

From the results, the average vertical velocity was computed, and also various interval velocities. As would be anticipated, the average velocity shows a fairly uniform increase with depth (Figure 5). The interval velocities vary significantly at various points, and these variations appear to correspond with some of the reflecting beds detected from the reflection spread.

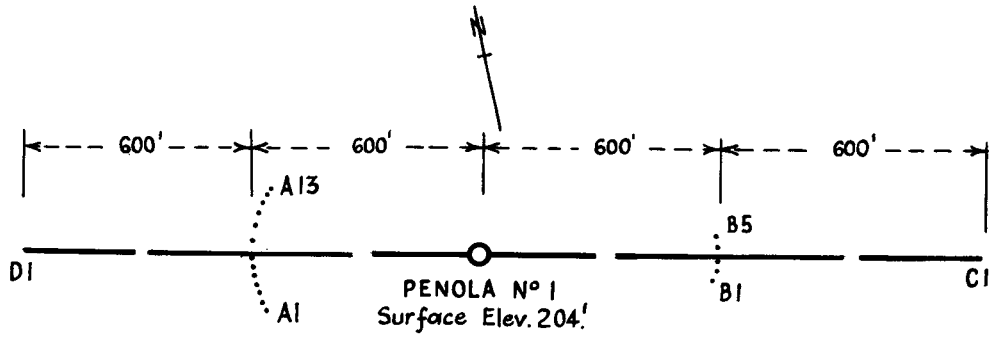


Fig. 4 **OIL DEVELOPMENT N.L.**
Plan of Shot holes for Velocity Survey
PENOLA No. 1

* Publication authorized by the Director of Mines, Department of Mines, South Australia.

FIG. 6

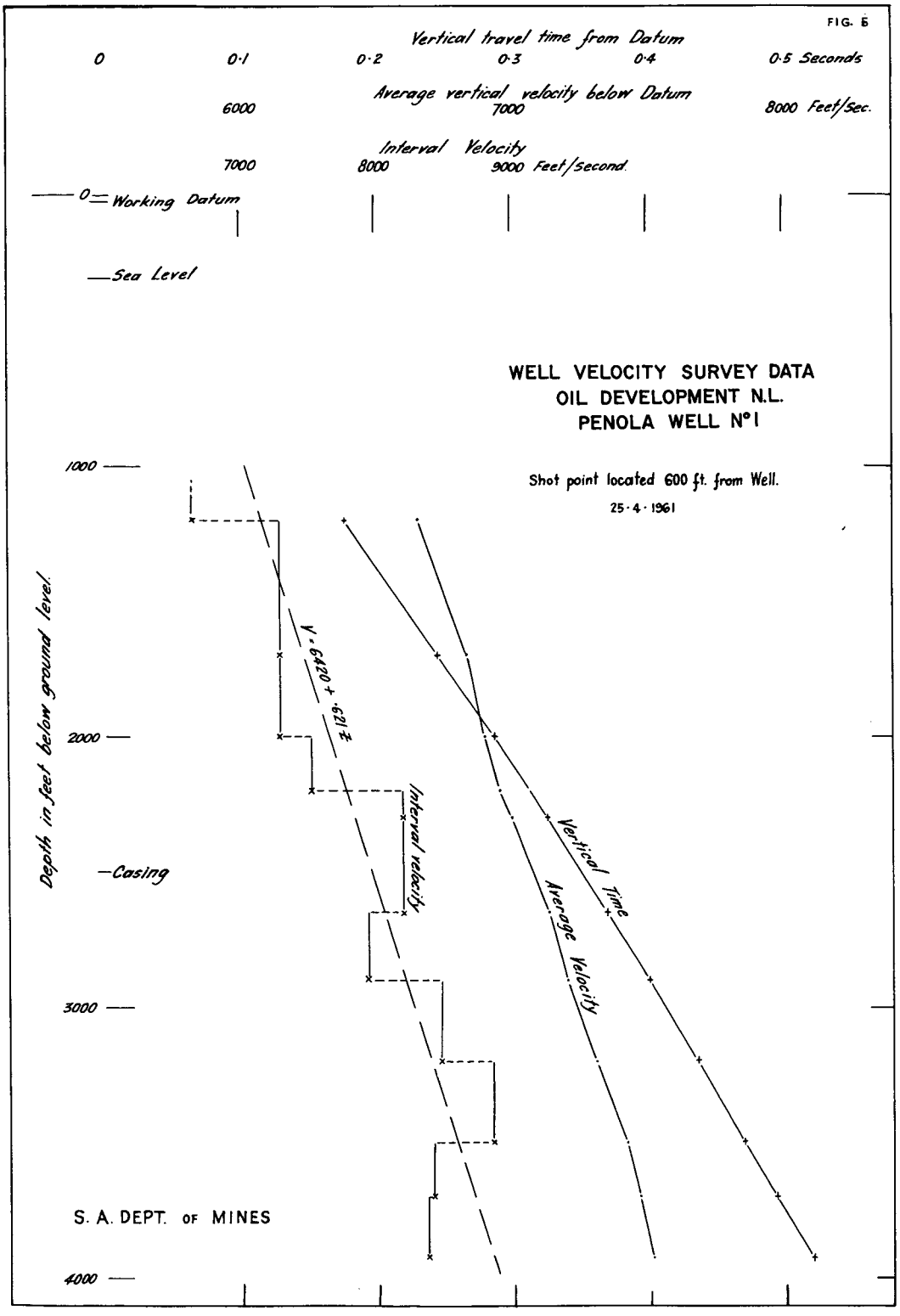

Vertical travel time from Datum
0
0·1
0·2
0·3
0·4
0·5 Seconds
Average vertical velocity below Datum
6000
7000
8000 Feet/Sec.
Interval Velocity
7000
8000
9000 Feet/second
0 = Working Datum
Sea Level
WELL VELOCITY SURVEY DATA
OIL DEVELOPMENT N.L.
PENOLA WELL N°1
Shot point located 600 ft. from Well.
25·4·1961
1000
2000
3000
4000
Depth in feet below ground level
Casing
V = 6420 + 6·21 Z
Interval velocity
Vertical Time
Average Velocity
S. A. DEPT. OF MINES

Fig. 6

Shothole Information—Elevation, Distance & Direction from Well

A 306' 600' 5° N of W
B 305' 600' 5° S of E
Datum Elevation 283'

Department of Mines Well

PENOLA N°1: Oil Development N.L.

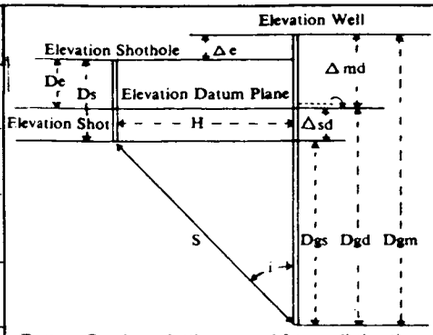
Elevation: 204'

Total Depth: 4985'

LOCATION

Coordinates | Section, Township, Range: Hd PENOLA Sec 500 | County: GREY | Area or Field

Record Number	Shothole Number	Dgm	Ds	tus	tr	T Reading	T Polarity	T Grade	Dgs	H	cotan i	cos i	Tgs	△sd	△sd/V	Tgd	Tgd Average	Dgd	△Dgd	△Tgd	Vi Interval Velocity	Va Average Velocity
1	B3	1200	21	·0075	·114	·199	D	G	1178	600		·89107	·1773	−1	−·0002	·1773						
15	A10	"	26	·012	·101	·198	D	VP	1172	"		·89105	·1764	3	·0006	·1770	·1771	1179	1179	·1771	6657	6657
2	B4	1700	28	·010	·114	—	D	VP	1671	"				6					500	·0686	7289	
14	A1	"	18	·010	·103	·262	D	VP	1680	"		·94177	·2467	−5	−·0010	·2457		1679				6834
13	A3	2000	17	·009	"	·301	D	VP	1981	"		·95707	·2881	−6	−·0012	·2869		1979	300	·0412	7282	6898
3	B2	2200	23	·009	·114	·325	D	VP	2176	"		·96402	·3133	1	·0002	·3135		2179	200	·0266	7519	6951
12	A6	2300	17	·008	·102	·338	—	VP	2281	"		·96711	·3269	−6	−·0012	·3257		2279	100	·0122	8197	6997
4	B4	2650	16	·008	·115	·382	D	F	2633	"		·97502	·3725	−6	−·0012	·3713			350	·0427	8197	
11	A8	"	17	·007	·101	·376	D	F	2631	"		·97534	·3667	−6	−·0012	·3655	·3684	2629				7136
10	A1	2900	28	·009	·102	·4075	D	P	2870	"		·97884	·3989	5	·0010	·3999		2879	250	·0315	7937	7199
9	A3	3200	28	·010	·103	·442	D	F	3170	"		·98256	·4343	5	·0010	·4353		3179	300	·0354	8475	7303
5	B4	3500	15	"	·114	·4775	D	P	3484	"		·98551	·4706	−7	−·0014	·4692		3479	300	·0339	8850	7415
8	A6	"	25	·009	·100	—	—	VP	3473	"				2					200	·0238	8403	
7	A10	3700	28	·010	·100	·4985	D	P	3670	"		·98691	·4920	5	·0010	·4930		3679				7462
6	A8	3925	28	"	·102	·525	D	P	3895	"		·98834	·5189	5	·0010	·5199		3904	225	·0269	8364	7509



Dgm = Geophone depth measured from well elevation
Dgs = " " shot
Dgd = " " datum
Ds = Depth of shot
De = Shothole elevation to datum plane
H = Horizontal distance from well to shotpoint
S = Straight line travel path from shot to well geophone
tus = Uphole time at shotpoint
T = Observed time from shotpoint to well geophone
tr = " " to reference geophone
Δe = Difference in elevation between well & shotpoint
Δsd = " " shot & datum plane
Δsd = Ds − De
Dgs = Dgm − Ds ± Δe : $\tan i = \frac{H}{Dgs}$

Tgs = cos i T = vert. travel time from shot elev. to geophone
Tgd = Tgs ± $\frac{\Delta sd}{V}$ " " datum plane " "

Dgd = Dgm − Δmd
Vi = Internal velocity = $\frac{\Delta Dgd}{\Delta Tgd}$
Va = Average " = $\frac{Dgd}{Tgd}$

Surveyed by S.A. Dept. of Mines
Date 25-4-1961
Weathering Data

V = 5100'/sec from Uphole Survey

Casing Record Cased to 2488'

Well Velocity Calculation Form

APPENDIX 10

POROSITY AND PERMEABILITY REPORT

O.D.N.L. PENOLA NO. 1 WELL

by

Petroleum Technology Laboratory

Bureau of Mineral Resources

Samples of Cores 8, 10, 11, 12, 14, 15 and 20 from Penola No. 1 were submitted for analysis.

Tests of porosity and permeability were carried out using Ruska field porometer and permeameter with air and nitrogen as saturating and flowing media. Extractions were made by Dean and Stark vapour method using toluene as solvent.

In the summary results, grain density equals the density of the solid matter itself, and bulk density equals the density of the bulk sample including pore space.

Petroleum Technology Laboratory, Bureau of Mineral Resources, Geology and Geophysics, Canberra

Date of Tests: March, 1962

CORE ANALYSIS RESULTS

Notes (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V & H) cut at right angles from the core or sample. Ruska field porometer and permeameter were used, with air and dry nitrogen, respectively, as the saturating and flowing media. (ii) Oil and water saturations were determined using Soxhlet type extraction apparatus. (iii) Acid solubilities were determined using 15% commercial hydrochloric acid. (iv) N.D. means Not Determined. (v) T.S.T.M. means Too Small To Measure.

Well or Area	Core or sample number	Depth in ft. From: To:	Effective porosity % by Vol.		Absolute permeability millidarcys		Avg. density in gms/cc.		Fluid saturation			Acid solubility	Oil Characteristics		
									Water: % pore space	Oil: % pore space	Oil: Metric tons/ acre ft	% by vol.	Fluorescence in solvent	Colour of extracted Oil	Fluorescence of extracted Oil
			V	H	V	H	Dry Bulk	Grain							
PENOLA No.1	8	2590'0" 2590'6"	24	26	2	Nil	2.00	2.60	28	Nil	Nil	8	N.D.	No colour in toluene	N.D.
PENOLA No.1	10	2994'8" 2995'5"	16	N.D.	Nil	N.D.	2.37	2.82	33	Nil	Nil	26	N.D.	No colour in toluene	N.D.
PENOLA No.1	11	3189'0" 3189'6"	36	N.D.	40	N.D.	1.84	2.87	9	Nil	Nil	7	N.D.	No colour in toluene	N.D.
PENOLA No.1	12	3363' 3373'	32	N.D.	1	N.D.	2.02	2.88	19	T.S.	T.M.	8	N.D.	Very faint pale yellow	N.D.
PENOLA No.1	14	3715' 3729'	16	16	Nil	Nil	2.13	2.54	40	T.S.	T.M.	4	N.D.	Faint blue-green bloom	N.D.
PENOLA No.1	14	Repeat extraction	-	-	-	-	-	-	43	T.S.	T.M.	-	N.D.	Faint blue-green bloom	N.D.
PENOLA No.1	15	3917' 3928'	21	19	5	N.D.	2.03	2.55	39	Nil	Nil	3	N.D.	No colour in toluene	N.D.
PENOLA No.1	20	4600'8" 4601'0"	20	24	Nil	4	2.21	2.81	23	Nil	Nil	4	N.D.	No colour in toluene	N.D.

Additional information: All cores received in an unsealed condition. Some difficulty was experienced in cutting the small plugs due to the friable nature of the rock and the small size of the samples. In some cases, therefore, only one determination of porosity and permeability could be made.

Plate 1 Sheet 1

COMPOSITE WELL LOG

COMPANY: OIL DEVELOPMENT N.L.

WELL NUMBER: PENOLA WELL No. 1

PETROLEUM TENEMENT
OIL EXPLORATION LICENCE No 22/1

STATE: SOUTH AUSTRALIA   4-MILE SHEET: PENOLA   BASIN: MURRAY   WELL STATUS: ABANDONED

OIL DEVELOPMENT N.L.

O.D.N.L. PENOLA WELL No.1 COMPOSITE WELL LOG

R. HARE & ASSOCIATES	VERTICAL SCALE: 1 inch=100 feet
Prepared by: J. CUNDILL	DRG. No. OD/53
Drawn: M.N.	
Date: 17. 7. 1961	

LOCATION – Lat. 37° 20′ 38″S Long. 140° 52′ 35″E
ELEVATION – Reference Pt (R.T.) 209·2 A.S.L.
Ground 204·2 A.S.L.

Date Spudded Feb. 7. 1961
Date Drilling Stopped: April 18. 1961
Date Rig Off: May 5. 1961
Total Depth: Driller 4985′
E.Log 4160′

Hole Size

In	From	To
12 1/4	0′	503′
8 1/2	503′	2501′
5 5/8	2501′	4985′

Casing

In.	Wt.	Gr.	Depth	Cmt.	Cmt'd. to
9 5/8	36lb	J55	497′	198sacks	Surface
7	20lb	J55	2488′	325sacks	Surface

Cement Plugs

From	To	Sacks
0′	80′	10
2455′	2507′	7
2901′	2934′	5
3962′	4008′	7
4175′	4211′	2 drums

	ELECTRIC LOG DATA					MICROLOG CALIPER DATA				
RUN NUMBER	1	2				1	2			
DATE	5/3/61	25/4/61				5/3/61	27/4/61			
FOOTAGE LOGGED	1990′	1672′				1988′	885′			
LOGGED FROM	2486	4159				2484	3372			
LOGGED TO	496	2487				496	2487			
TOTAL DEPTH - ELECTRIC LOG	2487	4160 *				2487	3375 *			
TOTAL DEPTH - DRILLER	2501	4985				2501	4985			
CASING SHOE - ELECTRIC LOG	496	2487				496	2487			
CASING SHOE - DRILLER	497	2488				497	2488			
BIT SIZE	8 1/2″	5 5/8″				8 1/2″	5 5/8″			
MUD-KIND	Water base	Water base				Water base	Water base			
TREATMENT										
WATER LOSS ccs/30 min	13 5	11·5				13 5	9			
WEIGHT lbs/cu. ft	77 5	75				77·5	76			
VISCOSITY (Marsh) Sec.	57	50				57	48			
pH		7								
RESISTIVITY Ω m²/m & TEMP — Rm	2·45 @ 75	1 6 @ 70				2 45 @ 75	1·8 @ 70			
Rmf	2 30 @ 75	1 5 @ 72				2 30 @ 75	2 4 @ 55			
Rmc	2 60 @ 75	1·95 @ 72				2 60 @ 75	2 8 @ 55			
MAX RECORDED TEMPERATURE	104°	146°				104°	124°			
ELECTRODE SPACING										
SYMMETRICAL	16″	16″				2″	2″			
	64″	64″								
NON-SYMMETRICAL	18′ 8″	18′ 8″				1″ × 1″	1″ × 1″			
RECORDED BY	B Boutan	B Boutan				B. Boutan	B. Boutan			

* Maximum depths to which logs could be run due to fish and tight hole.

Well Head Fitting: *Welded steel plate*
Drilled by: *Aust. Tube Wells*
Logged by: *J. Cundill P. Bollen*
Cemented: *Aust. Tube Wells*
Drilling Method: *Rotary*
Mud logging by: *J. Cundill P. Bollen*

LITHOLOGIC REFERENCE

Grit; Sandstone; Siltstone; Mudstone; Shale; Coal; Limestone; mi: Micaceous; cal: Calcareous; gl: Glauconitic; py: Pyritic; c: Carbonaceous; ch: Cherty

OTHER BORE HOLE LOGS

Velocity Survey conducted by S.A. Mines Dept.

WELL SYMBOLS

- Gas show slight
- Circulation loss, partial and S.G. mud
- Circulation loss, complete and S.G. mud
- Core interval number and recovery
- Formation test interval and no. (O.H.; In csg.)
- Plugged interval
- Fossils: Macro, Micro, Plant, Spore pollen

Lithology by: J. Cundill P. Bollen

Porosity based on E log Interpretation shown in black as "trace, poor, fair, good". Results from core analysis are included in separate appendix.

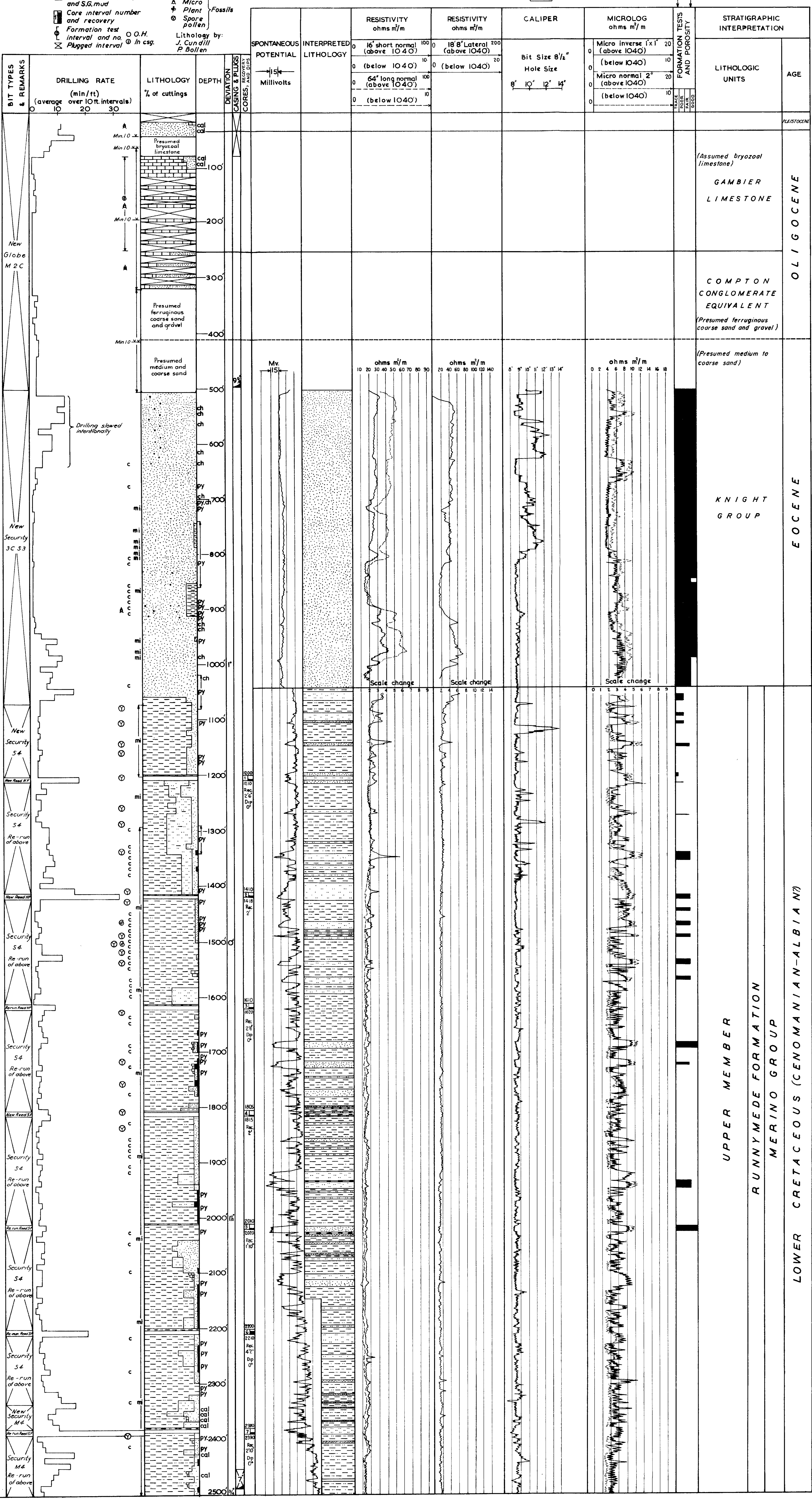


Plate 1 Sheet 2

STRATIGRAPHIC INTERPRETATION

AGE: LOWER CRETACEOUS (CENOMANIAN–ALBIAN?) | LOWER CRETACEOUS (APTIAN?) | JURASSIC(?)

LITHOLOGIC UNITS: UPPER MEMBER | COAL MEASURES LOWER MEMBER | RUNNYMEDE FORMATION | MERINO GROUP | MOCAMBORO MEMBER?

Unconformity?

FORMATION TESTS AND POROSITY — TRACE / FAIR / POOR / GOOD

DST 3 1&2 Misrun Packer Seats failed

DST 1 Rec. 4mud | Misrun Packer Seat failed

Misrun Packer Seat failed

MICROLOG ohms m/m — Micro inverse 1x1' | Micro normal 2"

CALIPER — Bit Size 5 ⅞" | Hole Size 5" 6" 7" 8"

RESISTIVITY ohms m/m — 18'8" LATERAL | 64' long normal | 16' short normal | 16' short normal amplified

for short and long normal, log refer to scale 1:20
for short normal amplified log refer to scale 1:4

INTERPRETED LITHOLOGY

SPONTANEOUS POTENTIAL — 15 Millivolts

WEMCO GAS DETECTOR operated from 4280' — Units on 10' Attenuation — Detector out of action

CORES: Rec. / Dip

CASING & PLUGS

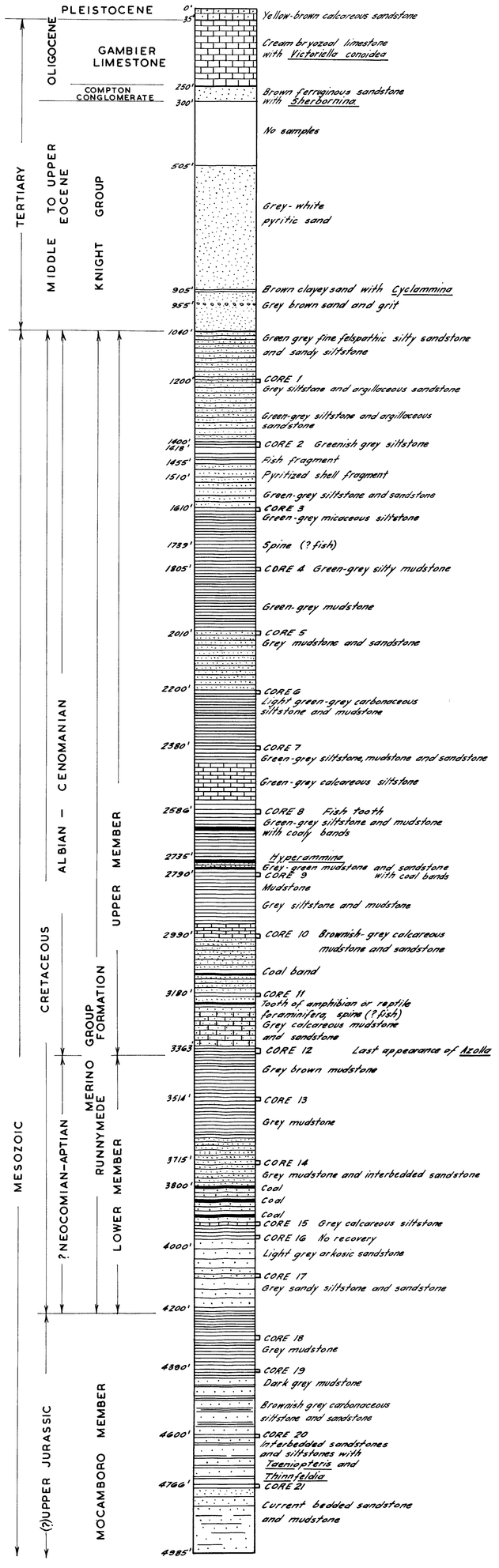
DEVIATION

DEPTH: 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500 3600 3700 3800 3900 4000 4100 4200 4300 4400 4500 4600 4700 4800 4900 5000

LITHOLOGY % of cuttings

DRILLING RATE (min/ft) (average over 10ft intervals)

BIT TYPES & REMARKS: Used Walker McDonald WM1 | New Walker McDonald WM1 | New Hughes OSC2 | New Hughes OWS | New Hughes HP1R | New Reed 2C



OIL DEVELOPMENT N.L.

PENOLA No.1 WELL

COLUMNAR SECTION

S.A. DEPT. OF MINES

To accompany report by N.H. Ludbrook.