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No Tenement

TENEMENT HOLDER: Mines Administration Pty. Ltd.

REPORT:

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1ST DRAFT

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Geological Study No. 16/1966.

A REVIEW OF THE RENMARK - CANEGRASS AREA, MURRAY BASIN, SOUTH AUSTRALIA

By:

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Mines Administration Pty. Limited,
31 Charlotte Street,
Brisbane

December 1966.

C O N T E N T S

ILLUSTRATIONS

Figure 1—Locality map showing the extent of the Murray Basin.

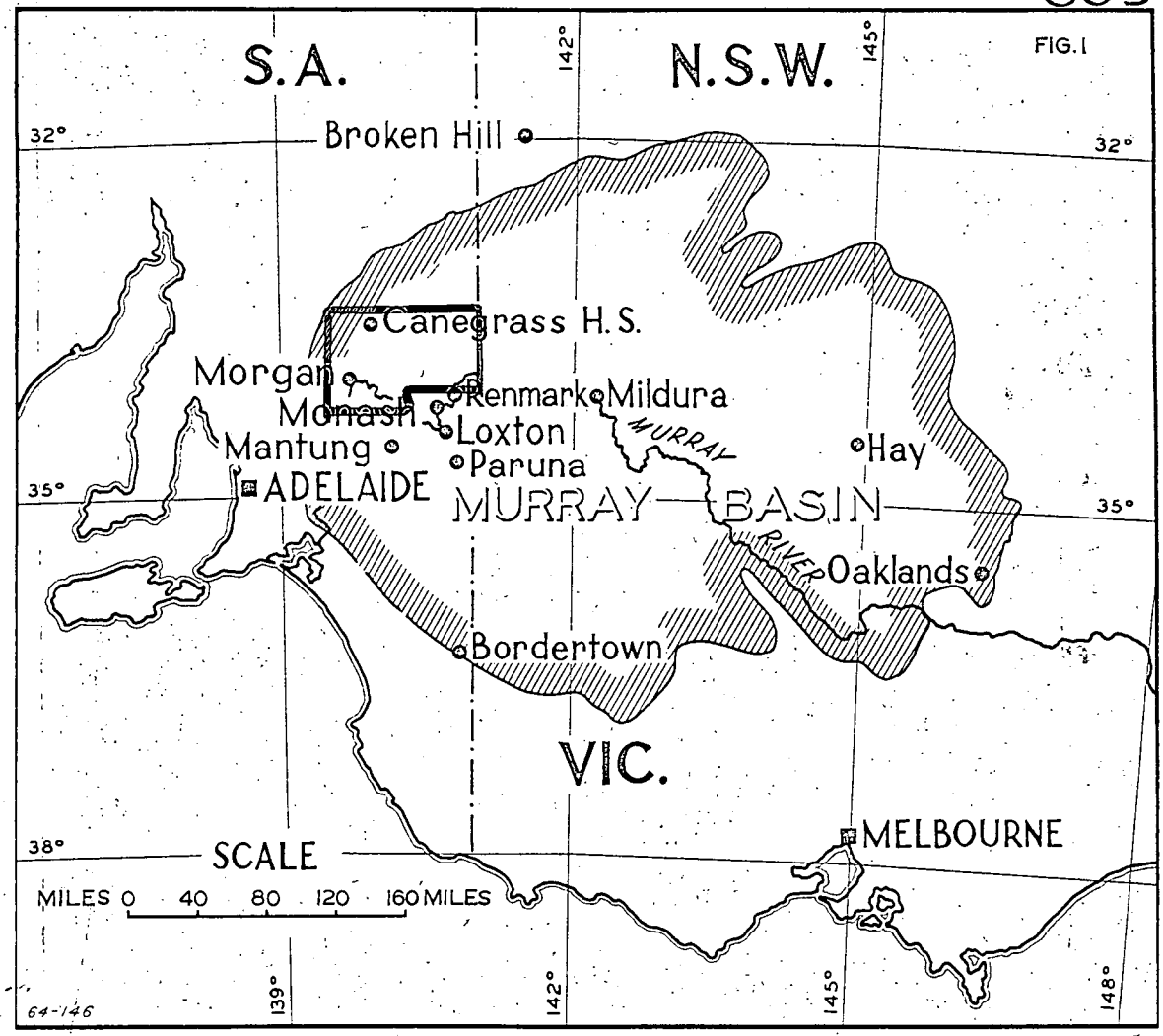

Figure 1

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INTRODUCTION

Applications have been called for a petroleum exploration licence over the area formerly covered by O.E.L. 35 South Australia (Figure 1). This area covers a part of the north-eastern flank of the Murray Basin. A considerable amount of basic exploration has been carried out and the broad prospects appear to be fairly well defined. The area is in a favourable geographical position and the petroleum prospects appear to be reasonable.

A brief study of the available data has been made in Brisbane and in Adelaide and the results are presented below.

LOCATION:

The application area covers approximately 5,000 square miles on the northwestern flank of the Murray Basin. It has a maximum width from east to west of 95 miles and from north to south of 57 miles.

The centre of the area is 120 miles from Adelaide, 150 miles from Broken Hill and 400 miles from Melbourne.

GEOGRAPHY:

The terrain is flat and generally between 100 and 300 feet A.S.L. The country along the western boundary begins to rise towards the eastern slopes of the Mt.Lofty Ranges and the 500 foot contour approximates the western boundary. There is almost no gradient on the Murray in this area and the levee banks are at about 100 feet A.S.L. South of the river is an intensively developed irrigation area. Extension swamps are present five to ten miles from the river, particularly upstream from Loxton.

Latitudional sandhills are developed to the north of the river between Waikerie and the N.S.W. border. These sanddunes are mainly vegetated and do not present a serious problem to cross country traversing.

The rainfall is 8 - 10 inches per year; fairly evenly distributed but with a slight winter maximum from May to September. Because of the low rainfall and absorbent, flat terrain there is no surface runoff or drainage except in the fair western portion of the area.

The southern margin of the area is very well serviced by bitumen roads on both sides of the Murray. North of the river there is a reasonable network of secondary gravel roads and station tracks. The towns along the Murray are the terminal of a number of rail lines from Adelaide servicing the irrigation areas to the south.

GEOGRAPHY: (contd.)

TENEMENT HISTORY:

The earlier tenement history has not been studied in detail. The Renmark - Canegrass area has formed part of the following permits:-

O.E.L. 11 (Australian Oil and Gas Corporation).

Covered an area of 18,000 square miles between 21/12/55 and 20/12/57 and 7,580 square miles from 21/12/57 to 20/12/58. Surrendered in 1958.

O.E.L. 23 (Hackathorn Oils Ltd.)

Covered the whole of the South Australian portion of the Murray Basin from the Padthaway Horst to the Olary Block. The permit was held for five years from 23/11/59 to 22/12/64. Renewal was refused on the grounds of non-compliance with the previous licence conditions.

O.E.L. 29 (Australian Oil Corporation)

This was a portion farmed out from O.E.L. 23. It was granted from 12/11/62 to 11/11/64. Renewal was refused on the grounds of default of licence conditions.

O.E.L. 35 (Tasman Oil Pty. Ltd.)

Same area as the present application area (5090 sq. miles) and was granted for one year from 22/2/65. No application was made for a renewal.

The permit was granted on a firt year's programme of a seismic survey with the drilling of a well as the second year's programme. Tasman carried out the Renmark Seismic Survey but elected to relinquish the area rather than drill a well. It is understood that Tasman's commitments in other areas (Bonaparte Gulf, Gulf of Papua) were a major reason for thier decision to drop the area.

PREVIOUS EXPLORATION:

Geological. A fairly comprehensive review of the geology of the whole of the Murray Basin and its marginal area was prepared by Frome Broken Hill Pty. Ltd. (Spence 1958). The stratigraphy of the Tertiary outcrop and subsurface sections in the South Australian portion of the Murray Basin has been described in detail

A summary of the oil prospect of the basin was published by Yakumin and Spigg (1963)

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PREVIOUS EXPLORATION: (contd.)

Geological (contd.)

by O'Driscoll (1960) and Ludbrook (1961).

Geophysical

Prior to 1962 most of the geophysical work in the area was to the south of the Murray ~~River~~ River. ~~A~~ comprehensive review of the geophysical exploration to the end of 1963 has been given by Seedsman (1964).

A regional aeromagnetic coverage ~~of~~ has been flown and total intensity maps have been produced.

Gravity surveys were made south of the river prior to 1960. Further gravity work, both north and south of the river, has been carried out since; some as part of the seismic survey programmes and some as part of the B.M.R. Helicopter Gravity programme. The ~~available~~ available coverage is shown on Sheets 1-3.

Comparison of the aeromagnetic and gravity results with the seismic data shows that both these tools are very useful in this area.

In 1960 the B.M.R. shot refraction traverses in the Loxton area as part of their Murray Basin Seismic Survey (Watson 1962). Further surveys south of the river were made in 1960 - 1962 by Hackathorn Oils (Denison and Denton 1961), Beach Petroleum (Stackler and Yakumin 1963) and the South Australian Department of Mines.

The first seismic surveys to the north of the Murray were carried out by the Department of Mines in 1962 (Seedsman 1962). Reflection lines were run between Chaffey and Conopus (Sheet 3 Line CC), Chaffey and Wentworth (CW) and from Renmark towards Morgan (RM). Several refraction probes were made along these lines and along a line from Morgan to the Pine Valley area ~~RR~~ (R1 - R14) (Sheet 4). This work was most significant as it confirmed the deep trough to the northwest of Renmark suggested by the gravity data. The Chaffey-Conopus line crossed the fault bounding the trough to the north-west. ~~It~~ the work also indicated an area of fairly deep section ~~near~~ near Canegrass Homestead ~~(Sheet 4)~~.

The Mines Department work was continued in 1963 (Seedsman and Kendall 1964) with a refraction line east from Canegrass to the New South Wales border ~~and~~ and a line northwest from Monash to intersect the Canegrass Line. Some reflection work was shot in the vicinity of the fault on the Monash line.

The Mines Department work in the area was completed in 1965 with a refraction line from ~~Hyp~~ Hyperna, on the eastern end of the Canegrass Line, northwest to about 10 miles north of Pine Valley Homestead. Reflection spreads were shot on the eastern ends of both this Hylpurna Line and the Canegrass Line

PREVIOUS EXPLORATION: (contd.)

Geophysical (contd.)

and the eastern end of the Canegrass refraction results were re-interpreted. (Kendall 1965).

The Hypurna Line was a continuation of the Nulla Nulla Line shot during a survey by the Mines Department on behalf of Australia Oil and Gas Corporation in their P.E.L. 5 (Moorcroft 1965).

The refraction work consisted generally of depth probes to establish the depth and sequence of refractors in each area and continuous refraction profiling to map basement. The results on the main traverses, Monash, Canegrass and Hypurna are shown on Sheet 5.

In the Renmark Trough the depth probes established the presence of a 14,000 ft./sec. refractor which is identified as originating from at or near the top of the Permian in A.O.G. North Renmark No.1.

The high speed refractor has a velocity generally between 16,500 and 19,900 ft/sec. and is taken to represent basement.

If it is correct that the 14000 ft/sec. refractor approximates the top of the Permian then the distribution of Permian section is probably as shown on Sheet 6. As seen here the Permian is in two main environments; a thick section in the Renmark Trough and a thinner section in a north-westerly trending lobe on the western flank of the Trough. This latter section is apparently 3,000 feet thick in the Canegrass area.

The presence in several places of refractors intermediate between the top of Permian and basement refractors, e.g. the 15,700 ft/sec. refractor at -6100 ft. on R.1 and the 15,900 ft./sec. refractor at -3250 ft. at Canegrass S.P. 975 may be indicative of the presence of pre-Permian sedimentary section.

As part of their exploration of the area in 1965 Tasman Oil conducted a three month reflection seismic survey in an attempt to establish closure against the boundary fault in the southern end of the Trough (Geophysical Associates 1965) No fault closure was proved but the work mapped the southern end of the fault in detail and suggested that both fault and anticlinal closures are still quite likely on the flanks of the trough (Sheet 7).

Two reflectors were mapped during the Renmark Survey. They were generally conformable and 80 - 120 m/s. apart. The upper reflector, Horizon K, has been tentatively identified as originating from the top of the sandy basal

PREVIOUS EXPLORATION (contd.)

Geophysical (contd.)

Aptian section occurring at 2870 feet in Renmark No.1. The lower reflection, Horizon L, has been identified as "approximate top of Lower Permian". This identification is not precise. No mappable events were recorded below Horizon L. The refraction results indicated a throw of ± 3,000 feet acorss the fault at basement level while the reflection results show throws of 350 - 700 ft. at the Cretaceous level. This suggests that the major part of the fault movements were pre-Cretaceous. If there were major post-Permian movements then it seems likely that Horizon L maps the unconformity at the top of the Permian rather than the internal structure of the Permian. If this is confirmed by further study then the design of methods to obtain intra-Permian structure is an important operational objective.

Drilling

The first well to penetrate pre-Tertiary sedimentary section in this part of the Murray Basin was the Loxton Farming Company Bore drilled in 1910 (Sheet 8). Palaeontological study of material from this well in the 1950's indicated that it had bottomed in Cretaceous section.

In 1956 A.O.G. Loxton No. 1 was drilled to confirm the presence of pre-Tertiary section suggested by the gravity results. It was completed at 1601 feet in Cretaceous section which was overlain by the Tertiary at 1350 feet. The presence of Kanmantoo erratics near the bottom of the section suggested that basement was not far below the total depth.

In 1961 A.O.G. Wentworth No. 1 was drilled to the east of the permit area. It encountered the section -

0 -	192	Quaternary sands
192 -	1273	Tertairy
1273 -	1604	Cretaceous
1604 -	2055	Lower Permian - mudstones
2055 -	2081 (T.D.)	Lower Permian - basal conglomerate

This was the first record of pre-Cretaceous section in the western half of the Murray Basin.

In 1963 B.P. N.L. Loxton No. 2 was drilled two miles northwest of A.O.G. Loxton No. 1 and encountered the section :-

011

0 - 1340	Tertiary
1340 - 1778	Cretaceous (marine)
1778 - 1804 (T.D.?)	Cambrian-Kanmantoo Group metamorphics

Following on the recognition of the Renmark Trough as a result of the Department of Mines seismic work in 1962, A.O.C. North Renmark No. 1 was drilled in 1963. The section was :-

0- 601	Quaternary
60 - 1800	Tertiary
1800 - 3245	Cretaceous - mainly marine
3245 - 4018(TD)	Lower Permian - marine glacials.

Although the well did not reach basement the results tended to confirm the prediction that approximately ~~6000~~ 5000 feet of section were present in this area.

Lake Victoria No. 1.

In 1964 B.P. N.L. Monash No. 1 was drilled near the southern end of the Renmark Trough and eight miles southwest of North Renmark No. 1. This well was not subsidised and the data has not been released. However the section was :-

0- 50 feet	Quaternary
50 -1760 feet	Tertiary
1760 - 2930 feet	Cretaceous
2930 - 3320 feet	Lower Permian
3320 - 3445(T.D.)	Lower Permian/? Devonian

The cuttings from below 3320 feet contained gragments of pinkish sandstones which may be of Lower Palaeozoic (?Devonian) age. However it is not know if they are present as a bedded section or as erratic boulders in the Permian glacial. In the following discussion it will be assumed that they are erratics. It should be noted that in the refraction probe R.1. six miles to the northwest a 15900 1/4 refraction was recorded at - 6100 feet which could represent the top of the Lower Devonian. The general isopachs suggest

that the horizon would be at a similar depth at the Monash location.

Unfortunately no logs were run in Monash No. 1 but a test of the Permian section indicated good porosity and permeability in water filled sands similar to those logged in the section between 3430 and 3785 feet in North Renmark No. 1.

In 1966 Beach drilled B.P. N.L. Berri South No. 1 on a small seismic closure 17 miles south of North Renmark No. 1 and 14 miles southeast of Monash No. 1. In this area refraction results indicated a high speed refraction of (19000 - 20000) ft/s at 2300 - 2400 feet. The well was programmed as a structural test near the zero edge of the Palaeozoic. No Permian was encountered and the section was :-

0 - 30 feet	Quaternary
30 - 1634 feet	Tertiary
1634 - 2128 feet	Cretaceous (conglomeratic at base)
2128 - 2176 (T.D.)	Kanmantoo Group metamorphics

TECTONIC SETTING

The previous exploration has established the broad tectonic features of the application area (Sheet 8). Refraction seismic and gravity data have been particularly useful in this regard.

The results indicate that the major feature is a northeast trending trough of thick pre-Cretaceous section. The deepest part of this Renmark Trough is near the southern end of the axis where 9000 feet of section is indicated including ± 5000 feet of pre-Cretaceous section. The trough shallows to the northeast and about 4000 feet of section (1500 feet of pre-Cretaceous) is present in the axis near the N.S.W. border.

On the southeastern flank of the trough there is a rapid thinning of the pre-Cretaceous against the flank of a parallel basement high running from the Loxton area to Lake Victoria. It is not known if this thinning is by truncation, onlap or depositional wedging but the correlation between ~~Monash~~, North Renmark and Berri South suggests that there is considerable onlap in the lower Cretaceous section at least (Sheet 10).

The southern end of the northwestern flank of the Trough is formed by a major down to the southeast fault. This fault, herein termed the Hamley ~~Overland Corner~~ Fault has a maximum displacement of ± 3000 feet at basement level and of 350-800 feet at the lower Cretaceous level.

The faulting decreases to the north and the northern part of the northwestern flank of the trough is formed by the Conopus Ridge, a basement feature between Hypurna and Canegrass (Sheet 6). The Permian section appears to pinchout on both flanks of this ridge.

The Trough narrows to the north and the pre-Cretaceous section thins considerably. It may pinch out entirely or it may be continuous, as a thin section, with a predicted trough of thick Permian in the Tararra area of P.E.L.5 (N.S.W.) being investigated by A.O.G.

The southern end of the trough is not defined. It is probable that the pre-Cretaceous does not extend south of the Murray. Although there is no evidence of faulting in the seismic coverage available but it is possible that the southern end is controlled by a northwest trending fault controlling the river course between Loxton and Overland Corner. If present this Fault would be an extension of the Murrayville Fault mapped to the southeast in Victoria (Sheet 8).

The form of the Canegrass Lobe is not well defined. It is mainly recognised from the refraction results on the western end of the Canegrass Line and from the refraction probes between Morgan and Pine Valley (Sheet 4 R6-R14). Its southeasterly extension towards the Renmark Trough is suggested by the gravity data and the refraction results on the Monash Line.

Between Canegrass and the Conopus Ridge the maximum depth of section is about 4350 feet near S.P.265. North of Canegrass on refraction probe R.12 the 19900 f/s basement refraction is at -4300 feet and the 14200 f/s refraction at -800 feet. To the west and north of R.12 all the other refraction probes (R9, 10,13,14) showed basement at shallow depths suggesting that the northern end of the lobe is limited by a fairly large fault. This conclusion is supported by the aeromagnetic data. On the refraction probes between Canegrass and Morgan pre-Tertiary section appears to be present at R8 (2100 feet) and R9 (500 feet). R9 is near Bunguania Bore which drilled 560 feet of presumable Palaeozoic sandstones between the base of the Tertiary and the Proterozoic basement.

On the Canegrass Line the level of the 14000 f/s refraction dips eastward from -450 feet near Canegrass to -2300 feet near Hypurna. Together with the Bunguania Bore results this suggests that there is no Cretaceous section in the northwestern part of the Canegrass Lobe.

TABLE I STRATIGRAPHIC UNITS OF THE WESTERN MURRAY BASIN

AGE		Group	Formation	Lithology	Environment	Interval in A.O.C.North Renmark No.1	Thickness in A.O.C. North Renmark No.I
QUATERNARY (60')				Sands and clays	Aeolian and fluviatile	0 - 60'	60'
	L.Pliocene		Loxton Sands	Unconsolidated yellow and grey sands with minor mudstones	Marine	60 - 140'	80'
T E R T I A R Y (1740 ft.)	U.Miocene - L.Pliocene		Bookpurnong Beds	Siltstones and sandstones, greenish with abundant glauconite	Marine	140 - 200'	60'
	Lower Miocene	Murray Group (230')	Pata Limestone	Grey, clayey mail, partly recrystallised limestone. Very fossiliferous	Marine	200 - 250'	50'
			Morgan Limestone	Fine grained cream - yellow and grey bryozoal limestone grading to marly limestone	Marine	250 - 450'	200'
			Mannum Formation	Yellow limonitic calcareous sandstones and limestones	Marine	450 - 530'	80'
	Oligocene	Glenelg Group (176')	Gambier Limestone	Fossiliferous mainly limestone. Very porous. Minor shale bands	Marine	530 - 656'	126'
			Ettrick Formation	Grey and green sandy clays and marls. Abundant fossils and glauconite	Marine	656 - 706'	150'
	Eocene	Knight Group (1094')		Quartz gravels and grits, carbonaceous clays and silts, medium carbonaceous sands. Raw lignites	Paralic to non-marine	706 -1800'	1094'
				UNCONFORMITY			

C R E T A C E O U S (1445')	?Cenomanian - Albian		Greenish grey, very fine to fine sandstones and siltstones with minor mudstones. Spores and fish remains, no foraminifera.	Paralic (? ≒ Winton Formation)	1800 - 2405'	605'
	Aptian	upper unit	Shales and siltstones with minor sandstones, some of which are porous.	Marine	2405 - 2840'	435'
		lower unit	Interbedded shales, siltstones and sandstones. Some sandstones are coarse and porous. Metamorphic rock erratics.	Marine	2840 - 3015'	175'
	?Neocomian		Interbedded sandstones and shales. Sandstones are dominant, mainly medium grained and porous. Rare coal lignites.	Apparently no foraminifera. Probably parallic	3015 - 3245'	230'
			UNCONFORMITY			
P E R M I A N (773+')	Lower Permian (U.Sakmarian-L.Artinskian)	upper unit	Shales and siltstones, minor tight sandstones. Slump structures and erratic pebbles	Glacial marine	3245 - 3430'	185'
		middle unit	Interbedded sandstones, siltstones and shales. Boulder beds in core. Many of the sandstones appear to be porous.	Glacial marine	3430 - 3785'	355'
		lower unit	Shales and siltstones with minor sandstones including fontainbleau sandstones, Slump structures and erratics	Glacial marine	3785 - 4018' (T.D.)	233'
	Lower Palaeozoic		Reddish sands and conglomerates	No cores, no pre-Permian fossils in cuttings. Age very tentative.	Section in Monash No.1 3320-3445 (T.D.)	Thickness in Monash No.1 125'

STRATIGRAPHY

The area is almost entirely blanketed by Quaternary sands and alluvials Some outcrops of Tertiary are present, mainly in the incised banks of the Murray. A great number of water bores have been drilled in the Tertiary section. Together with sections in quarries, drainage channels etc. these have been the main source of data on the Tertiary stratigraphy.

Beyond the western border metamorphosed Proterozoic and Cambrian sections outcrop in the Mt. Lofty-Olary Arc. In the western half of the area these metamorphics underlie the Tertiary at shallow depths.

The main features of the stratigraphic sequence known from outcrop and subsurface information are given in Table 1. Additional features of the broader stratigraphic units are discussed below.

Pre-Permian.

There is no positive confirmation for the presence of pre-Permian sections in the Renmark Trough. However as a maximum of ~~5500~~ 5000 feet of pre-Cretaceous section is indicated from refraction work it is possible some of this may be pre-Permian.

Thick ~~U~~ upper Devonian-Lower Carboniferous sections are present along the northern rim of the Murray Basin to the east of Broken Hill and were drilled in M.E. Blantyre No. 1.

At W.O. N.L. Balranald No.1, 160 miles east of Renmark, steeply dipping Ordovician shales were encountered below the Tertiary. On some of the refraction probes in the Renmark area there is a $\pm$ 15500 $\frac{1}{5}$ refract~~ion~~ or between the top of Permian and basement refract~~ions~~ors. It is speculated that this refract~~ion~~or could arise from the top of a pre-Permian Palaeozoic section.

In Monash No. 1 cuttings below 3320 feet contained fragments of pinkish sandstones which could be of Devonian age. It is not known if they occur as pebbles and boulders within the Permian or as bedded sections. No cores were taken and no pre-Permian microfossils were found. At the nearby refraction probe R1 a 14800 $\frac{1}{5}$ refract~~ion~~or was recorded at -4500 feet and a 15700 $\frac{1}{5}$ refract~~ion~~or at -6100 feet (Seedsman 1963).

For the present it is assumed that these sandstones are from ~~sandstone~~ pebbles and boulders within the Permian.

These velocities appear to be slightly anomalous and the data on this line should probably be re examined

Permian

In the western half of the Murray Basin Permian sections have been drilled in A.O.G. Wentworth No. 1 (477$^+$feet), A.O.C. North Renmark No.1(773$^+$feet)

and B.P. N.L. Monash No. 1 (±750+feet). With the possible exception of Monash (see above) the entire Permian section has not been drilled in any well.

If the 14000 1/s refraction represents approximately the top of the Permian section then the distribution and thickness of the Permian is generally as shown on Sheet 6. There is a maximum of 5000 ~~5500~~ feet in the Renmark Trough and a probable maximum of about 3500 ~~4000~~ feet in the Canegrass Lobe.

~~The~~ Wentworth No. 1 is on the other side of a major basement ridge to the Monash-Renmark section. The section was of white silty clay and sandstone overlying a hard conglomerate which is probably a basal conflomerate (M.Rose pers.comm). Some plankton are present but no definite marine fauna was found.

The North Renmark No. 1 section may be divided into upper and lower shaly units and a middle unit containing a good development of porous and permeable slatwater filled sands (Table 1 and Sheet 9). A similar section is reported from Monash where a drill stem test indicated good porosity and permeability. Unfortunately no logs were run on Monash No. 1.

The refraction results suggest a total section of 6000-7000 feet at Monash and about 5000 feet at North Renmark. At Berri South No.1, 14 miles southeast of Monash the Cretaceous rests on basement indicating a rapid pinchout against the flank of the basement high.

At present there appears to be no definite evidence as to whether this thinning is ~~xxxxxx~~ by onlap, depositional wedging or truncation. The presence of saline waters suggests that the basin may be closed. If the thinning is by onlap or wedging there are good prospects of major stratigraphic traps along the flank of both the ~~southeastern~~ Lake Victoria and Cnopus highs.

Cretaceous

The Cretaceous sections encountered in the Murray Basin are shown in Table 2.

WELL	Interval From	Interval To	Thickness	Underlying Formation
North Renmark No. 1	1800	3245	1445	L. Permian
Monash No. 1	1760	2930	1170	L. Permian
Loxton Company Bore	1596	1805	209 +	T.D.
Loxton No. 1	1350	1601	251 +	T.D.
Loxton No. 2	1340	1778	438	Kanmantoo
Berri South No. 1	1634	2128	494	Kanmantoo
Lake Victoria No. 1	1780	2320	540	Kanmantoo
Wentworth No. 1	1273	1604	331	L. Permian

Table 2. Cretaceous Sections in the Murray Basin,

The information currently available to the author on the distribution of the Cretaceous is very incomplete, however the distribution is probably approximately as shown on Sheet 8.

As indicated on Table 2 the maximum Cretaceous section is in the Renmark Trough. Here it is 1000 - 1500 feet thick compared with about 500 feet on the basement high to the east. Both the lithological and palaeontological data suggest that much of the thinning is by onlap of the lower section (Sheet 10). This is also suggested by the seismic data in the Loxton and Combool Swamp areas (Seedsman 1963).

In North Renmark No.1 the main potential reservoirs in the Cretaceous are associated with the lower part of the Aptian and the ?Neocomian. This section does not appear to be present in the thinner sections flanking the trough.

Tertiary

The Tertiary section is about 1250-1750 feet thick and consists of about 500 feet of marine sandstone marls clays and limestones overlying a paralic to non-marine sequence of sands and gravels with minor clays (Knight Group). The Tertiary sequence has been described in detail by Ludbrook (1961). The section is probably thickest in the Renmark Trough and major facies changes are known. However most of the section is probably open to outcrop as subcrop under a thin veneer of Quaternary sands and alluvials.

STRUCTURE

Faulting appears to be the dominant structural mechanism in the South Austrlian portion of the Murray Basin. The eastern edge of the Mt. Lofty - Olany Arc is related to a meridonal fault in the south anf the northeasterly trending Redan Fault in the Olary region (Spemce 1958).

Between Swan Reach and Morgan the course of the Murray is controlled by the Morgan Fault (Sheet 10..). The displacement of the fault is down to the east and is well documented from water bore data. It extends northwards past Morgan to the northwestern margin of the basin near Alexandria Homestead. Several parallel faults including the Florieton Fault, occur to the west of the Morgan Fault. The Morgan Fault has displaced the Tertiary section. O'Driscoll (1960 p. 132) considered that faulting originated in the pre-Tertiary and possibly continued until quite recent times.

The sharp change in the course of the Murray between Loxton and Overland Corner is directly on trend with the Murrayville Monocline, a major lineament with northeastern Victoria. Although there is no faulting evident in the Tertiary section along the river it seems probable that the alignment is not conincidental and that the change in river course is related to a subsurface structural feature. There is no evidence of faulting on the seismic data but this may be due to the location and quality of the data. As stated previously it is speculated that this lineation marks the southern end of the Renmark Trough.

The main subsurface structural information comes from the Renmark Seismic Survey (Geophysical Associated 1965) and is limited to the southerwestern end of the Renmark Trough (Sheet 11). This shows a northeast trending synclinal axis about four miles northwest of North Renmark No.1. To the southeast the section is presumed to rise onto the flanking basement high. To the northwest the structure rises to the Hamley Fault. This feature appears to be a fault-fold system showing a total displacement of about 800 feet at the lower Cretaceous level. On Line 1 and on the Chaffey-Conopus line the feature appears to be a single fault. On line 3 it is a series of small faults and on Line 5 the steep monoclinal fold is probably unfractured. No faulting was recognised on Line 6 suggesting that either the fault dies out or it swings to the north along the eastern flank of the Conopus High. No closures were mapped against the fault but it is still possible that such are presetn particularly in the area where the Chaffey-Conopus Line crosses the trend.

While the reflection work indicates a maximum post-Cretaceous movement of about 800 feet across the structure the refraction results suggest about 3,000 feet of movement at basement level. This pre-Cretaceous movements of about 2,000 feet appear to

have taken place. It is suspected that some at least of this movement took place during the Permian and had a marked effect on deposition.

Anticlinal structural patterns are developed along the northeastern margin of the Renmark Survey. A possible closure of 150 - 200 feet over about 20 square miles (the North Coombool Prospect) was mapped near the intersection of Lines 2 and 6 and a sharp anticlinal nose is suggested by the results on the northeastern end of Line 2.

The regional refraction lines indicate considerable local basement relief and it seems probable that associated structures may be developed in the overlying sedimentary section.

GEOLOGICAL HISTORY

The current study has been of the nature of a preliminary review so that it is unlikely that all significant evidence relative to the geological history of the area is known to the author. However it is hoped that the major features have been recognized and discussed.

Palaeozoic sedimentation in the Renmark area began during or before Sakmarian times on a metamorphosed Proterozoic and ?Cambrian topography. Deposition was probably centred around a half graben depression formed by the movements along the Hamley ~~Overland Corner~~ fault trend. From the evidence of other related areas of Permian deposition (Peake and Dennison Ranges, Coopers Creek Basin) fault movements probably continued during deposition and had had important effects on the style of deposition. The nature of the lower section is unknown but during Sakmarian times marine clastics derived from glacial terrains were being deposited. It is probable that the area of deposition gradually extended by onlap onto the flanks and around the northern nose of the Lake Victoria High and westward beyond the Hamley ~~Overland Corner~~ Trend into the Canegrass Nose. At present the upper limit of Permian deposition ~~in this area~~ is unknown but in other basins it continued into the Upper Permian as a coal measures sequence. It is possible that coal measures are present in the axial part of the Renmark Trough.

In the Renmark area Permian (or Palaeozoic) deposition probably reached a maximum thickness of over 6,000 feet.

A long period of uplift and erosion followed during the Triassic and Jurassic. ~~followed during which~~ much of the upper part of the Permian was eroded so that the present distribution is mainly confined to structurally low areas.

Sedimentation was resumed during the Cretaceous ~~possibly~~, initially in a parallic, then later in a marine environment which was ~~probably~~ continuous from the Great Artesian Basin in the north to the offshore Otway Basin in the south. Again deposition of a localised thick section may have been a response to movement on the Hamley ~~Overland Corner~~ trend. During the upper Aptian and Albian the area of sedimentation widened by onlap onto the surrounding highs.

A period of emergence and erosion followed, probably during the Paleocene. Sedimentation resumed during the Eocene with the deposition of the Knight Group, a fairly thick sequence of quartz sands and gravels deposited in a parallic to non-marine environment. The environment became marine during the Oligocene and this situation continued into the Lower Pliocene. During this marine phase a thin sequence of sandstones marls, limestones and mudstones were deposited in an extensive shallow water environment.

By the end of the Pliocene the area was again emergent and the subsequent Quaternary deposits consist of a thin veneer of fluvial - lacustrine sands and clays and alolian deposits.

PETROLEUM PROSPECTS

Pre-Permian

Although pre-Permian sections are suspected to be present in the axis of the Renmark Trough. However as their nature is unknown no comment can be made on their petroleum potential.

Permian

Only the upper 773 feet of the Permian section has been drilled so that the following appreciation, derived from this section, could be quite misleading. A restricted foraminferal fauna was recorded from cuttings throughout the section and on this evidence it is considered to be marine. The section consists of irregularly bedded shales, siltstones, and sandstones and pebble beds. Slump structures are common in the finer grained rocks. Sorting is generally poor although the logs indicate a considerable thickness of porous sandstone. The section is interpreted as marine deposition of material derived from a glacial terrain. As such it is thought to be a poor to fair source section. However the source characteristics of this type of deposition have not been studied by many workers. Sprigg (1966) has presented qualitative arguments that these sections could have good source characteristics. The one source rock analysis of material from this section indicated the presence of organic carbon including hydrocarbon compounds containing more than 15 carbon atoms (0.23% organic carbon, 96 ppm. C15+ hydrocarbons).

The sequence below the North Renmark section is unkown. However two points may possibly be significant: in Jerilderie No.1, 300 miles east of Renmark two thousand feet of normal marine section underlie a conglomeratic section "similar to the lower part of Wentworth No.1", and Ludbrook considered that the glacial section in Renmark was younger than the glacials in the Peake and Denison Ranges section. Both these facts give some support to the hope that more normal marine sequences may underlie the section drilled in the Northern Renmark No.1.

The electric logs indicate about 160 feet- of good reservoir sands in the North Renmark No.1 section. No porosity logs were run. However a test of a similar Permian section in ~~EXMXRXEX~~ B.P.N.L. Monash No.1 indicated good permeability and porosity. No logs were run in Monash.

The refraction data indicates a rapid thinning of the Permian on the flanks of the Renmark Trough. If this thinning occurs by onlap or by depositional wedging there is a good possibility of stratigraphic trapping along the flanks of the Conopus and Lake Victoria Highs. The possible structural closure near the intersection of Lines 2 and 6 of the Renmark Seismic survey is underlain by about 2500-3000 feet of ~~xRxxxxx~~ Permian section.

In the ~~Eax~~ Peake and Denison Ranges intra-Permian faulting has been shown to have had significant effects on the local depositional style. Similar effects are thought to have been active in the Gidgealpa and Moomba areas of the Coopers Creek Basin. Subject to further details on these locations it seems probable that the search for fault traps ~~axxxx~~ along the ~~Overland Corner~~ Hamley Fault may be of considerable interest.

In summary it appears that the Permian is a potential source section but of unknown quality; significant reservoir intervals are present; structural traps are very ~~xxxxx~~ likely, stratigraphic traps are probable and fault-straigraphic traps possible.

Cretaceous

The Cretaceous section ~~are~~ is thickest in the Renmark Trough. In North Renmark No.1 the basal part consists of a 400 foot section of sandstones with ~~xx~~ interbedded shales. This section is probably parallic to non marine. The upper part is Aptian the lower section is possibly ~~Cenonavian~~ Cenomanian. This unit is overlain by 1100 feet of shales and siltstones with minor sandstones and rare limestones containing a generally impoverished marine fauna. The section appears to have moderate source rock characteristics.

The sandstones of both the basal and upper sections appear to have reasonable porosity and permeability and to be salt water filled. No tests have been made. In general the reservoir character appears to improve towards the base of the unit.

The Cretaceous is also folded over the Permian structural prospects. The Cretaceous thins onto the flanking highs and there is fair evidence that much of this thinning is by onlap of the lower section.

In summary the Cretaceous appears to be a fair - moderate source section with significant reservoir units. Structural and stratigraphic traps ~~ae~~ are both probable.

Tertiary

The major part of the Tertiary section consists of the apparently non-marine Knight Group. This is overlain by shallow marine units having ~~fair~~ some ~~xxxx~~ source character. Although the data is not precise there seem to be major facies changes in the Tertiary section.

Reservoir sections are plentiful and the Tertiary forms an important aquifer section. There are about 130 wells in the area north of the Murray. Although no detailed study has been made it is probable that 30-40 of these obtain their supplies from the Knight Group. As no significant hydrocarbon shows have been reported from the Tertiary it appears that the petroleum ~~pozpoz~~ prospects are low. However they probably cannot be entirely overlooked.

EXPLORATION PROGRAMME

(a) Prospects

The main avenues for exploration appear to be:

(i) Search for structural prospects in the Renmark Trough.

(ii) " " " " " Canegrass Lobe.

(iii) " stratigraphic (-structural) prospects on the northwestern flank of the Lake Victoria High.

(iv) Search for stratigraphic (-structural) prospects on the flanks of the Canopus High.

(v) Search for fault-stratigraphic prospects along the ~~Overland Corner~~ Hawley Fault.

(i) Structural Prospects - Renmark Trough

The most promising prospect at the moment appears to be the possible closure at the intersection of lines 2 and 6 of the Renmark Survey (North Coombool Prospect). A programme of seismic work, probably both reflection and refraction, appears ~~desirable~~ desirable to establish closure and the depth and nature of the section.

As noted previously the most promising structural area appears to be to the north of the Renmark Survey area and a regional seismic coverage appears desirable in this area.

(ii) Structural Prospects -Canegrass Lobe

The nature of the Canegrass ~~Lobe~~ Lobe is not known ~~to~~ in any degree of detail. In particular the ~~assumption~~ assumption of a continuous section joining the Canegrass area to the Renmark Trough needs confirmation. Also the situation on the ~~upthrown~~ upthrown side of the ~~Overland Corner~~ Hawley Fault, to the west of the Renmark Survey coverage, is not well known.

The data in this area is limited to the B.M.R. Helicopter Gravity data. At this stage it would appear that additional gravity data would be desirable as a first step.

A gravity survey based on two east-west traverses ~~for~~ from about the Radium Hill Power line into the Renmark Trough are ~~proposed~~ proposed. The traverses would be about 10 miles apart. The ~~nor~~ northern traverse would be about 10 miles south of the Canegrass Line through Glue pot Homestead. The southern traverse would begin a few miles south of the Bungunnia Bore. In addition the seismic traverses of the Renmark ~~Line~~ Survey would be metered where the survey data is available.

The gxxxxx gravity programme would probably be followed by exploratory seismic work.

(iii) Stratigraphic Traps on the flank of the Lake Victoria High

Following a detailed review of the previous seismic data the investigation of this prospect would probably commence with a seismic traverse from near the intersection of the Chaffey-Conopus and Chaffey - Wentworth Lines near Woolpalool Swamp south-east to the southereastern corner of the permit. Some indications of onlap have aaaaaaa already been noted in this area.(Seedsman 1963)

(iv) Stratigraphic Traps on the flank of the Canopus High

At this stage xxxxxxx these prospects are quite speculative. Exploration in this area can be expected to developed from the structural examination of the xxxxxx northern Renmark Trough and of the Canegrass Lobe.

(v) Fault traps along the ~~Overland Corner~~ Hamley Fault

The most promising area for this type of prospect appears to be in the vicinity of the Chaffey-Conopus and Renmark Survey Line 6, traverses. Seismic work in this area will probably be associated with the general regional coverage proposed for the northern Renmark Trough.

(b) Programme

The primary objective of the Group's initial programme in the area ~~will~~ should be to establish, as soon as possible, a location for a stratigraphic test well of a thick section in the Renmark Trough. The character of the major part of the pre-Cretaceous section is completely unknown. It is felt that the source and reservoir potential of this section can be best established by drilling a well on a prospect having some possibility of being a hydrocarbon trap. At this stage the most probable locations appear to be

(1) On the North Coombool Prospect

(2) On a fault prospect on the northern end of the ~~Overland Corner~~ Hamley Fault

(3) On some other structure in the northern Renmark Trough

These conclsuions form the basis for the following programme:

(i) Review of Available Data

Initially a detailed ~~review~~ review of the available data will be undertaken to confirm or modify the conclsuions drawn in this preliminary review. In particular the geophysical data will be

studied in an attempt to establish the method or combination of methods most applicable to this area.

(ii) Gravity Survey

The prospects of Canegrass Lobe are much less ~~completely~~ known than those of the Renmark Trough. This area appears to have potential and in order to bring the knowledge of this area closer to that of the Renmark Trough it is proposed that a short gravity survey be undertaken at an early stage.

From the available data it seems probable that gravity is a very useful exploration method in this area. It seems possible that the correlation of gravity with future seismic and drilling data may allow it quite reliable use as both a regional and detailed structural method.

(iii) Seismic Survey

The major immediate exploration phase will be the programming and conduct of a seismic survey to establish a location for a stratigraphic test well. The programme will begin with detailing on the North Coombool Prospect followed by regional to detailed work in the northern Renmark Trough and near the northern limit of the Hamley Fault. A basic programme as shown on Sheet 4 is envisaged. The detailed methods to be used have yet to be determined but the survey will probably involve both reflection and refraction methods. A concentrated effort will be made to obtain structural data from within the pre-Cretaceous section for comparison with the unconformity and Cretaceous data.

If significant closure exists on the North Coombool structure it is possible that a location could be confirmed within one month's programme. If this is possible the remainder of the programme would be directed towards regional data.

At this stage a three month's survey is expected with a probable minimum of two months. Three months work is expected to cost about $120,000 - $150,000. Tentatively the survey is expected to commence in mid 1967.

(iv) Drilling

The primary objection of the geophysical work will be to obtain a prospective drilling location in an area of the Renmark Trough having about 6000 feet of total section. If this can be established a well to basement should be drilled to establish the nature and potential of both the Cretaceous and pre-Cretaceous section. At present the most promising feature is the North Coombool feature. In this location the section is expected to be very approximately :-

0 - 1750 Tertiary

1750 - 3500 Cretaceous

3500 - 6000 Permian (+? and pre-Permian)

6000 - T.D. Kanmantoo basement

If the exploration results allow the early selection and drilling of a well in the Renmark Trough an effort should be made within the two year commitment, to establish and drill a second stratigraphic test location, probably in the Canegrass Lobe.

A well in the Renmark Trough to 6000 feet is expected to take 1½ months and cost $100,000 - $130,000.

A well in the Canegrass Lobe to 4000 - 5000 feet is expected to take about one month and to cost $80,000.

(v) Summary

The exploration programme is expected to be :-

Detailed review and compilation	Feb.- April 1967
Gravity Programme $20,000	Apr. - May 1967
Seismic Survey 3 months (min.2 months) $120,000 - $150,000	May - July 1967
Renmark Trough Stratigraphic Test $100,000 - $130,000	Nov. - Dec. 1967
Additional Geophysical Work (± $50,000)	Mar. - April 1968
Canegrass Lobe Stratigraphic Test $70,000 - $90,000	July - Aug. 1968

Minimum total commitment for 2 years $300,000

BROKEN HILL

BROKEN HILL BLOCK

OLARY ARC

MURRAY BASIN

LOFTY MARGIN OF MOUNT OLARY

ADELAIDE

Olary

Peterborough

Burra

Blantyre N°1
9 miles east of border

Menindee

Pooncarie

Darling River

Ana Branch

Canopus N°2

Tararra

Canopus N°1

Canopus High

Canopus H.S.

Hyburna H.S.

Canegrass H.S.

CANEGRASS LOBE

Bungunnia Bore

Fault

Florieton Fault

Morgan Fault

Hamley Fault

Renmark Trough

Morgan

Swan Reach

Renmark

North Renmark N°1

Monash N°1

Lake Victoria N°1

Wentworth N°1

Wentworth

Murray River

MILDURA

Company Bore

Berri South N°1

Loxton

Loxton N°2

Loxton N°1

Balranald N°1
27 miles east of border

Murray Bridge

Pinnaroo

Murrayville Monocline

Marmon Jabuk Scarp

PADTHAWAY RIDGE

139°

140°

142°

32°

33°

34°

35°

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WESTERN MURRAY BASIN

TECTONIC ELEMENTS

0 10 20 30 40

Scale in miles

AUTHOR: V.G. Swindon	MAP NO: 10828	FILE LOC: F. 12
DATE: December, 1966	SHEET 1	

GRS 6061/36/40 / ENV. 715-1

MORGAN VALE H.S.

STURT VALE H.S.

PINE VALLEY H.S.

LORDS WELL H.S.

CANOPUS H.S.

HYPURNA H.S.

CANEGRASS H.S.

PARCOOLA H.S.

BALAH H.S.

GLUEPOT H.S.

BUNYUNG H.S.

Conopus No. 2.

Bungunnio Bore

HYPURNA LINE

CANEGRASS LINE

MONASH LINE

NORTH COOMBOOL PROSPECT.

A.O.C. North Renmark No.1.

B.P.N.L. Monash No.1.

B.P.N.L. Berri South No.1.

Company Bore

B.P.N.L. Loxton No.2.

A.O.G. Loxton No.1.

MORGAN

WAIKERIE

MURRAY RIVER

KINGSTON

L. BONNEY

RENMARK

PARINGA

MONASH

BERRI

LOXTON

MAGGEA

BLANCHE TOWN

PARUNA

R.1. R.2. R.3. R.4. R.5. R.6. R.7. R.8. R.9. R.10. R.11. R.12. R.13. R.14. R.M.

A. B. C. D. E.

CC. CW.

1. 2. 3. 4. 5. 6. 7.

N.S.W.

S.A. VIC.

139°30' 139°45' 140°00' 140°15' 140°30' 140°45' 141°00'

33°15' 33°30' 33°45' 34°00' 34°15' 34°30' 34°45'

LEGEND

DEPARTMENT OF MINES — REFRACTION PROBES.

" " " REFRACTION PROFILING.

CC " " " REFLECTION PROFILING.

BEACH PETROLEUM N.L. REFLECTION PROFILING.

TASMAN OIL PTY. LTD. REFLECTION PROFILING.

TENTATIVE FUTURE TRAVERSES.

EXPLORATION WELLS.

WATER, COAL BORES ETC.

FORMER BOUNDARY OF O.E.L. 35.

TOWNS

HOMESTEADS.

MINES ADMINISTRATION PTY. LTD.

RENMARK – CANEGRASS AREA, S.A.

SEISMIC TRAVERSES

SCALE IN MILES

4 3 2 1 0 2 4 8

Author : V. G. SWINDON.

Date : DECEMBER, 1966.

FILE LOC. F 16

MAP No. 10857

SHEET 2.

GRS 6061/36/40/ EHV 715 – 2

STURT VALE H.S.
PINE VALLEY H.S.
LORDS WELL H.S.
MORGAN VALE H.S.
CANOPUS H.S.
HYPURNA H.S.
CANEGRASS H.S.
PARCOOLA H.S.
BALAH H.S.
GLUEPOT H.S.
BUNYUNG H.S.
R.11 -500'
R.13 -500'
R.14 -600'
R.10 -2000'
R.9 -200'
R.12 -4300'
R.8 -2200'
R.7 -1400'
R.6 -900'
R.3 -1800'
R.4 -750'
R.5 -250'
R.2 -2500'
Canopus No.2. ± 800
-1650'
-2800'
-1100'
-3900'
-3050'
-3600'
-2700'
-1000
-2000
-3000
-4000
-5000
-6000
-8000
HYPURNA LINE
CANEGRASS LINE
MONASH LINE
HAMLEY FAULT
NORTH COOMBOOL PROSPECT
-4300'
-4000'
-3300'
-6600'
-8700'
-6100'
-7550'
-5700'
A.O.C. North Renmark No.1.
B.P.N.L. Monash No.1.
-4000'
MORGAN
-439'
-231'
-475'
-1800'
-2700'
WAIKERIE
MURRAY RIVER
KINGSTON
L. BONNEY
MONASH
BERRI
RENMARK
PARINGA
Company Bore
B.P.N.L. Berri South No.1. -1947'
LOXTON
B.P.N.L. Loxton No.2.
A.O.G. Loxton No.1.
BLANCHE TOWN
MAGGEA
PARUNA
R.M.
F.P.
CC
CW
N.S.W.
S.A. VIC.
139°30'
139°45'
140°00'
140°15'
140°30'
140°45'
141°00'
33°15'
33°30'
33°45'
34°00'
34°15'
34°30'
34°45'

LEGEND

- DEPARTMENT OF MINES — REFRACTION PROBES.
- " " " REFRACTION PROFILING.
- CC " " " REFLECTION PROFILING.
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- EXPLORATION WELLS.
- WATER, COAL BORES ETC.
- FORMER BOUNDARY OF O.E.L. 35.
- TOWNS.
- HOMESTEADS.

BASEMENT CONTOURS — FROM REFRACTION & DRILLING DATA.

LIMIT OF PRE-CRETACEOUS (MAINLY PERMIAN) TAKEN FROM DRILLING AND REFRACTION DATA. LIMIT OF 14000'/s REFRACTOR TAKEN TO BE LIMIT OF PRE-CRETACEOUS.

REFRACTION PROBES.

Refraction Data derived from South Australia Department of Mines Surveys.

MINES ADMINISTRATION PTY. LTD.

RENMARK - CANEGRASS AREA, S.A.

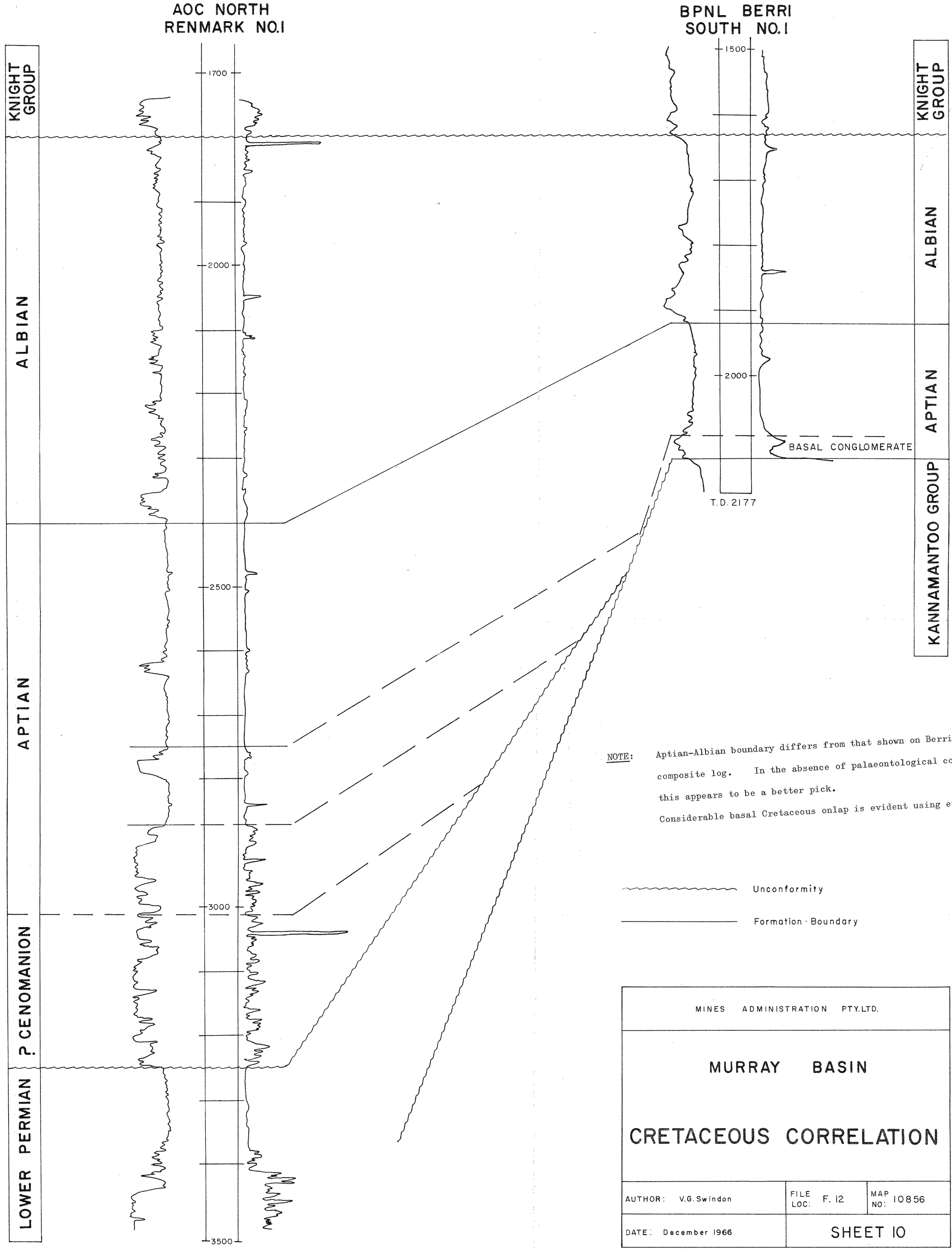
BASEMENT CONTOURS

SCALE IN MILES

4 3 2 1 0 2 4 8

Author : V.G. SWINDON.		
Date : DEC., 1966.	FILE LOC. F 16.	MAP No. 10855
	SHEET 6.	

GRS/6061/36/40/ENV 715 - 3



NOTE: Aptian-Albian boundary differs from that shown on Berri South composite log. In the absence of palaeontological control this appears to be a better pick.
Considerable basal Cretaceous onlap is evident using either pick.

Unconformity

Formation - Boundary

MINES ADMINISTRATION PTY.LTD.

MURRAY BASIN

CRETACEOUS CORRELATION

AUTHOR: V.G. Swindon	FILE LOC: F. 12	MAP NO: 10856
DATE: December 1966	SHEET 10	