REPT.BK.NO. 73/304

GEOLOGICAL SURVEY

A SUMMARY OF CERTAIN SEDIMENTARY BASINS IN SOUTH AUSTRALIA

B.E. MILTON

I.J. TOWNSEND

R.C.N. THORNTON

B.C. YOUNGS

Department of Mines
South Australia —

DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
PETROLEUM DIVISION

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by

B.E. MILTON
SENIOR GEOPHYSICIST
SEISMIC GEOPHYSICS SECTION

and

I.J. TOWNSEND
R.C.N. THORNTON
B.C. YOUNGS

GEOLOGISTS
PETROLEUM GEOLOGY SECTION

Rept.Bk.No.73/304
G.S. No. 5308
DM. No.715/72

17th December, 1973

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DEPARTMENT OF MINES
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*A SUMMARY OF CERTAIN SEDIMENTARY BASINS IN SOUTH AUSTRALIA

THE ARCKARINGA BASIN - B.E. Milton

The Arckaringa Basin is an intracratonic Permian basin, extending from the central northern part of South Australia to the southwest (figs. 1 & 2) and covering about 10^7 ha. It is composed of a central area of shallow crystalline basement with deep grabens or half grabens around the periphery. The central plateau is clearly outlined on the Bouguer gravity and magnetic basement contour plans. It consists of crystalline rocks of the Gawler Platform which vary in depth from near surface on the Mabel Creek, Coober Pedy and Mount Woods basement ridges to more than 1 000 m in the Mount Willoughby trough. The basement surface is gently undulating and is generally overlain directly by Permian sediments.

The marginal features consist of the Boorthanna trough in the east, the Wintinna trough in the north-west which is paralleled by the Tallaringa trough in the southwest, and the Phillipson and Wallira troughs in the south central area. Each of the first three contains a considerable thickness of pre-Permian dolomitic rocks while the sedimentary fill in the Phillipson and Wallira troughs is mainly Permian. Any pre-Permian sediments in these two features are thin and confined to their deepest parts. Permian sediments in the troughs range in thickness from less than 200 m at the culmination of the Wintinna gravity high to more than 1 200 m in the Boorthanna, Phillipson and Wallira troughs. Over most of the basin area, the Permian sediments are overlain by the Mesozoic rocks of the Great Artesian Basin.

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*Contributions prepared for publication in A.I.M.M. petroleum volume.

LEGEND

GRAVITY CONTOURS (20 milligal intervals) — 20 / 0

INFRABASIN LIMITS SHOWN

GRAVITY HIGH

GRAVITY LOW

WELL, DRY AND ABANDONED

PEDIRKA

BASIN

ARCKARINGA

BASIN

NORTHERN TERRITORY

SOUTH AUSTRALIA

QUEENSLAND

WESTERN AUSTRALIA

NEW SOUTH WALES

HALE RIVER 1

McDILLS 1

PURNI 1

WITCHERRIE 1

MT. CRISPE 1

MOKARI 1

PUTAMURDIE 1

PANDIEBURRA 1

OODNADATTA 1

POONARUNNA 1

KALLADEINA 1

SOUTHERN OCEAN

FIG 1. - Arckaringa - Pedirka Basin Gravity Contour Map

0 KILOMETRES 300

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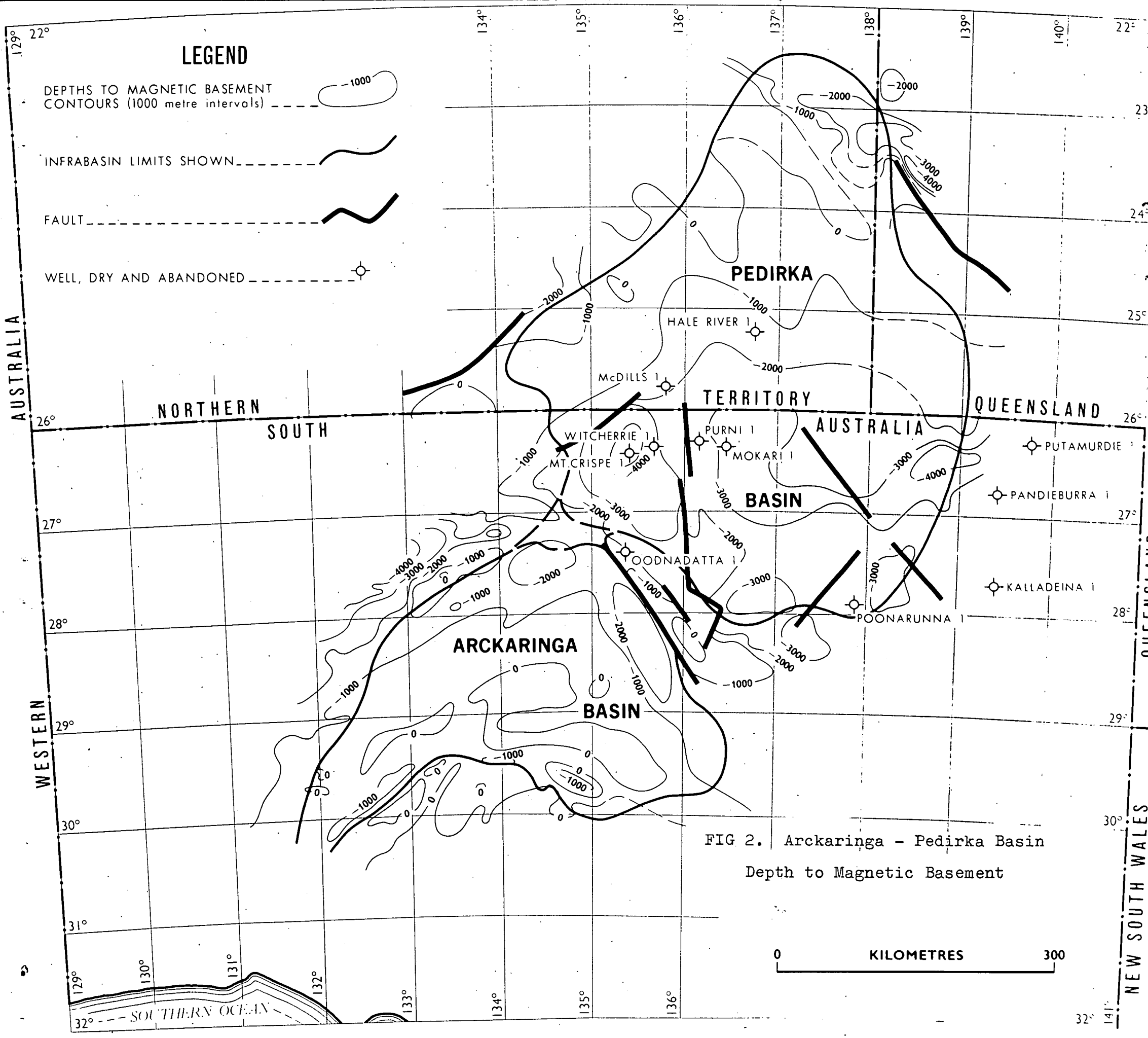

FIG 2. Arckaringa - Pedirka Basin
Depth to Magnetic Basement

The sedimentary sequence comprises, in ascending order, diamictites and cyclically graded greywacke (Boorthanna Formation), a dark coloured shale sequence (Stuart Range Formation) and dark grey micaceous siltstones, sandstones and coal seams (Mount Toondina Formation). These sedimentary horizons give rise to good seismic reflection and/or refraction events and have been mapped by these methods over large areas.

The basin was established by downfaulting of the graben structures in late Carboniferous - early Permian times, but shortlived movements along the same trends had already occurred in the Devonian. Upfaulting of adjacent basement blocks created uplands on which plateau glaciers formed during the early Permian. Moraines and eskers were deposited along the basin margin from where glacial debris was transported into the distal troughs by mudflows and turbidity currents. From available evidence, it would appear that Permian glaciation concluded in mid-Sakmarian time and that the cyclically graded greywackes are largely the product of post-glacial turbidity currents, fed by detrital material maintained at a high rate by continuous movements along the marginal faults. Tectonic stability in the late Sakmarian produced a low energy marine environment in which the dark shales of the Stuart Range Formation were deposited. Temporary evaporitic conditions have been recorded in some localities and these conditions are thought to be responsible for the low diversity of the foraminiferal fauna. Regression of the sea in the early Artinskian was brought about by renewed diastrophism and the freshwater silts, sands and coals of the Mount Toondina Formation, deposited under a moist subtropical climate, concluded the Permian depositional cycle.

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THE ARROWIE BASIN - I.J. Townsend

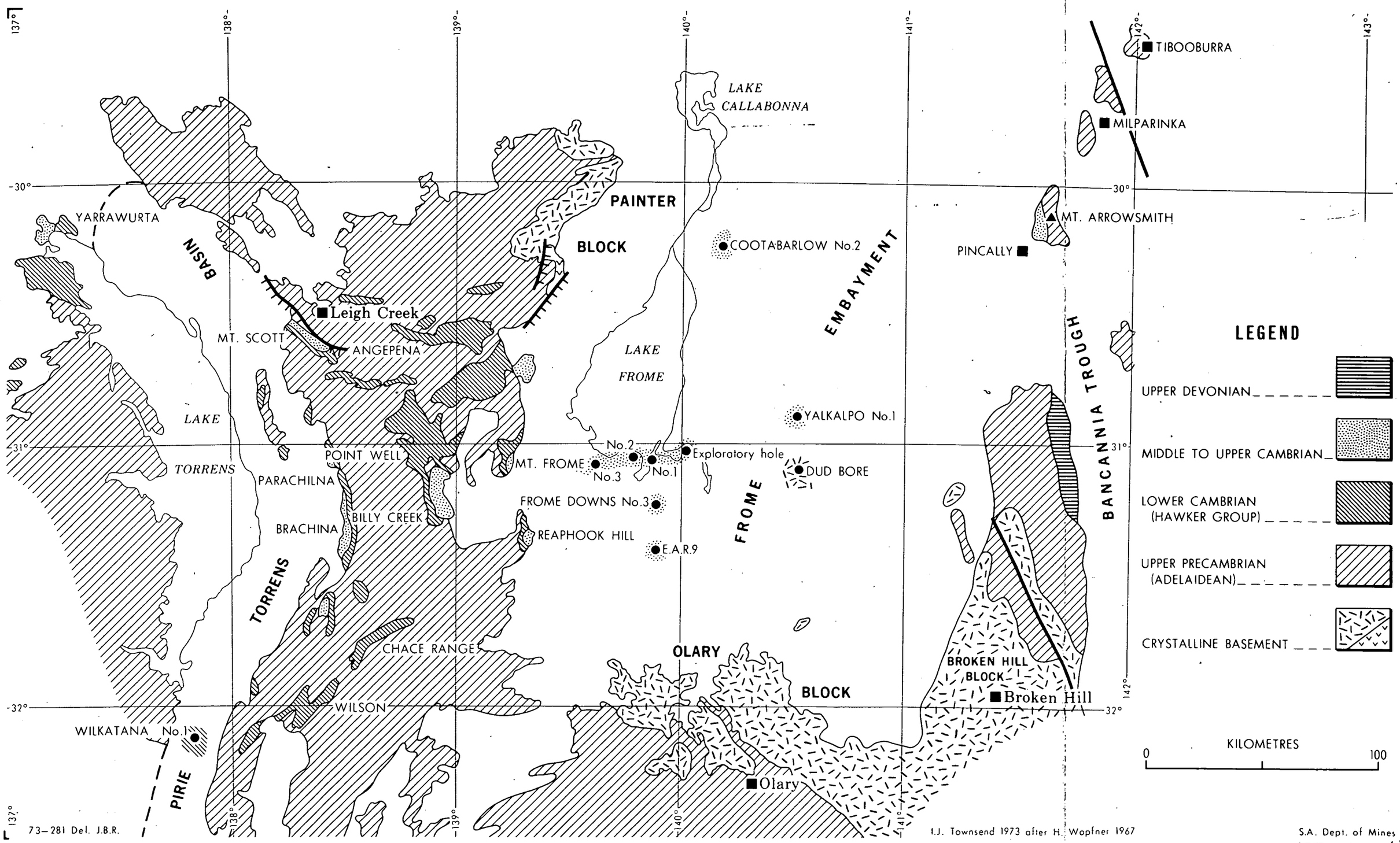
The Arrowie Basin is a Cambro-Ordovician basin covering the area from the western side of Lake Torrens east to the Tibooburra-Broken Hill trend, (Fig. 3). The southern boundary is the Olary-Broken Hill trend and the northern boundary is uncertain but lies approximately at the latitude of $29^{o}30'$S. The Flinders fold belt now separates the Pirie-Torrens Basin to the west and the Frome Embayment to the east.

The Arrowie Basin was most probably terminated by orogenic movements in the Late Cambrian to Early Ordovician, forming the Northern Flinders Ranges. The Pirie-Torrens Basin and the Frome Embayment are very much younger structural features within the older Arrowie Basin.

PIRIE TORRENS BASIN

The Pirie - Torrens Basin is a Tertiary sedimentary basin situated between the Arcoona Plateau to the west and the Northern Flinders Ranges to the east (Fig. 3). It is elongated greatly in a north-south direction and covers an area of approximately 10^{6} ha.

The sediments include dolomitic sandstones and dolomites overlying carbonaceous sandstones, siltstones and mudstones in the Lake Torrens sunkland (Bore 3A). Here the Tertiary sediments reach a maximum of 220 metres and are capped with approximately 90 metres of Holocene sediments.



73–281 Del. J.B.R.

I.J. Townsend 1973 after H. Wopfner 1967

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73-281/4
994·2+4

FIG. 3 *MAP SHOWING ARROWIE BASIN*

Outside the Torrens sunklands a maximum of 187 metres of lignitic clayey sands has been intersected in Wilkatana No. 12, a stratigraphic bore drilled by Santos. Palynological examination of samples from Lake Torrens Bore 3A (Johns, 1968) indicate an Eocene age of the sediments intersected.

Artesian waters are present in the sandstones of the Pirie - Torrens basin but supplies are small and salinities range from 2 000 - 72 000 ppm. Traces of oil have been detected in these sands but it is assumed the cause was migration from the underlying Wilkawillina limestone of the Arrowie Basin.

Below the Tertiary accumulations of the Pirie-Torrens basin lie the Cambrian sediments of the western Arrowie Basin. These sediments consist of dolomitic and sandy limestones. All of the subsurface information results from 23 shallow stratigraphic wells in the Wilkatana area and 2 near Parachilna, drilled by Santos Ltd. from 1955 to 1958. The deepest of the Wilkatana wells, Wilkatana No. 1 was drilled to a depth of 2 207 feet (673 m). It intersected 464 feet (141 m) of Tertiary sands and thin Holocene sands and clays. The next 873 feet (266 m) were Lower Cambrian limestones and the bottom 970 feet (296 m) consisted of Marinoan purple shales, part of the Adelaide System of Proterozoic rocks. Several of the Wilkatana wells lie on an east-west line through Wilkatana No. 1 and these have been included in figure 4 to construct the section through portion of the Pirie-Torrens Basin.

Some of the limestones intersected at Wilkatana, have a low vuggy porosity and traces of crude oil were recovered from a number of wells. The crude oil consisted of wax residues and a paraffinic crude of 26^{o} API gravity.

The vuggy dolomitic limestone which produced the bituminous material, is correlated with the Wilkawillina Limestone. The Wilkawillina Limestone is a Lower Cambrian carbonate sequence which contains beds of dark grey bituminous limestones.

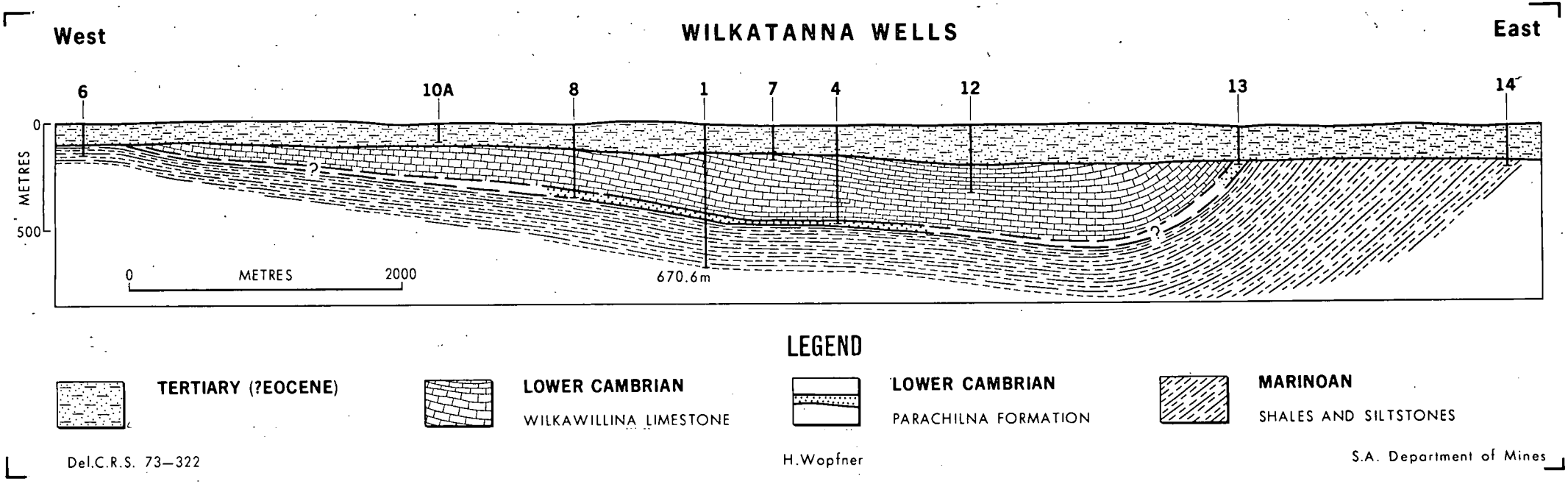


FIGURE 4.

DIAGRAMMATIC WEST-EAST SECTION OF THE WILKATANNA WELLS. PIRIE TORRENS BASIN

Wopfner (1970) suggests that the hydrocarbon bearing rocks were exposed to prolonged erosion and oxidation prior to renewed burial in Tertiary time, and the hydrocarbons at Wilkatana are only remnants of an Early Cambrian oil accumulation. As Middle and Upper Cambrian sediments are not present in the Wilkatana wells erosion must have reached the Wilkawillina Limestones and most of the hydrocarbons escaped. The hydrocarbon potential for the Cambrian sediments below the Pirie-Torrens Basin is therefore considered to be very low.

THE FROME EMBAYMENT - B.E. Milton

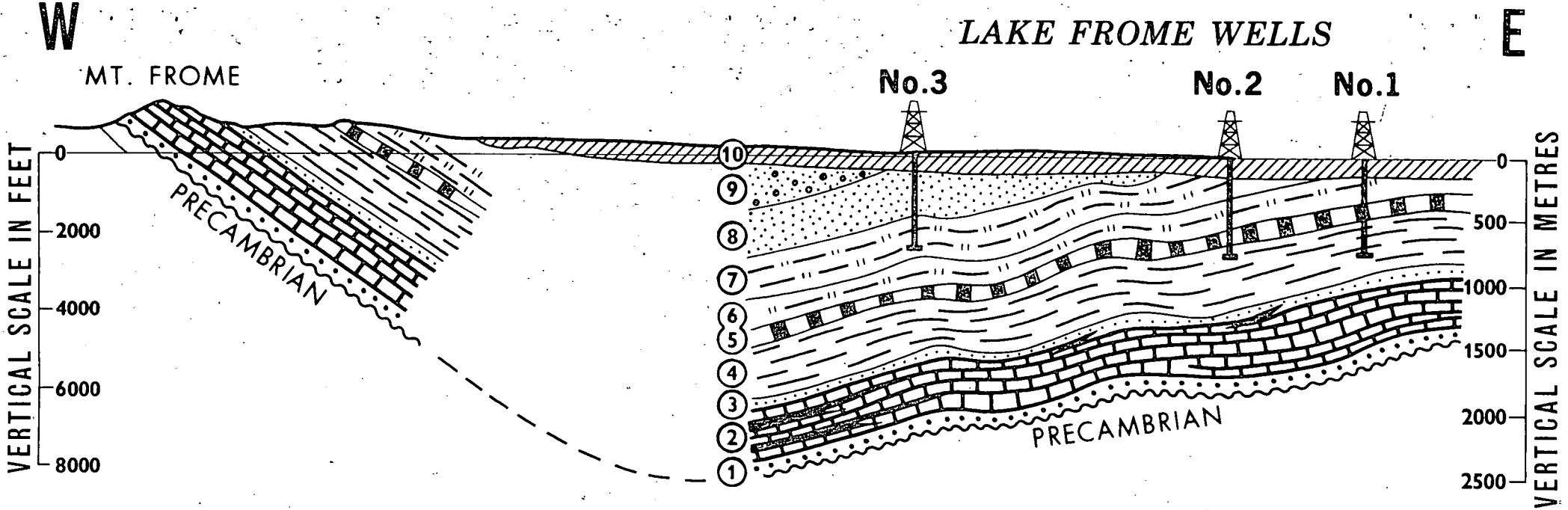
The Frome Embayment, which covers an area of about 5×10^6 ha, is the southernmost extension of the Great Artesian Basin in South Australia. It lies mostly in the central eastern region of South Australia, but extends into western New South Wales (Fig. 3). The Great Artesian Basin sediments of Jurassic to Cretaceous age range from a thin veneer in the south to about 600 m in the north. The whole of the Frome Embayment is underlain by a thick sequence of sedimentary rocks of Cambrian and Precambrian age. Interpretation of magnetic and gravity data suggests the presence of more than 4 500 m of sediments in places.

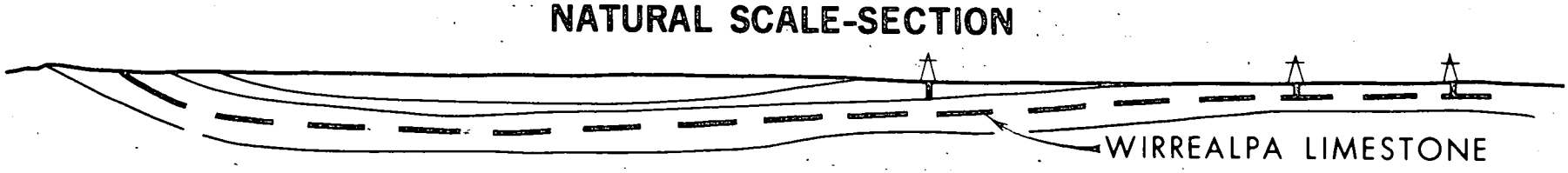
The Embayment is bounded in the east largely by the Precambrian sedimentary and metamorphic rocks of the Barrier Ranges, in the south by crystalline basement and some infolded Adelaidean strata of the Olary - Broken Hill block, and in the north-west by granite and related igneous rocks of the Painter block. The western margin abuts the fold belt of the Flinders Ranges, where the contact is partly formed by major fault zones, particularly in the vicinity of the Painter Block. Although the northern boundary is not as clearly defined as those already described, it can be approximately delineated by a latitudinal basement ridge centred about the parallel of $30^{\circ}S$, and having strong gravity and magnetic expression. This ridge also appears to form the southern limit of the Permian sediments of the Cooper Basin.

Hydrocarbons have been detected in outcropping Cambrian sediments adjacent to the western margin of the Embayment, and the possible presence of source and reservoir rocks in the Embayment has resulted in considerable geophysical exploration being carried out. To 1973 only shallow exploratory wells have been drilled. Those which penetrated Cambrian sediments are shown in Figure 3.

More than 1 600 km of seismic profiling was carried out in the Lake Frome region of the Embayment between 1962 and 1970 in attempts to delineate structural drilling targets. The seismic exploration has mapped the base of the Mesozoic section and the Middle Cambrian Wirrealpa Limestone over much of the area. Some discontinuous deeper events, possibly originating from Lower Cambrian strata, have been recorded, particularly in the south-east part of the region. No structural prospects of any magnitude have been detected, and the seismic results indicate a relatively uncomplicated Cambrian basin with little faulting and folding. Seismic contours of the top of the Wirrealpa Limestone in the Lake Frome area, extending as far north as Lake Callabonna, show the main trend of the Embayment to be northerly, changing to north-north-easterly in the northern part of the area. This agrees with the broader trends indicated by magnetic and gravity surveys. The deepest reflection to the Wirrealpa Limestone is about 2 100 m, 20 km east of Mount Frome.

Figure 5 presents a correlation section between the Cambrian exposures at Mount Frome and geological logs of the Delhi-Santos stratigraphic wells Lake Frome Nos. 1, 2 and 3 with extrapolation between control points based on the seismic reflection from the Wirrealpa Limestone. This section is consonant with the seismic interpretation in this area of a gently westerly dipping Cambrian sequence below the Mesozoic blanket of the Embayment.





REFERENCE

CAMBRIAN

⑩ MESOZOIC TO RECENT
⑨ GRINDSTONE RANGE SANDSTONE
⑧ PANTAPINNA SANDSTONE
⑦ BALCORACANA FORMATION
⑥ MOODLATANA FORMATION
⑤ WIRREALPA LIMESTONE
④ BILLY CREEK FORMATION
③ BUNKERS SANDSTONE
② WILKAWILLINA LIMESTONE
① PARACHILNA FORMATION

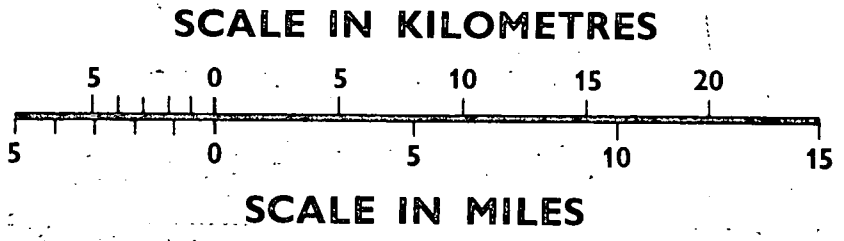


FIG 5. Geological Section

SW FROME EMBAYMENT

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THE MURRAY BASIN AND ASSOCIATED INFRABASINS - R.C.N. Thornton

INTRODUCTION

The Murray Basin is a shallow, saucer shaped Tertiary basin, covering an area of 31.3×10^6 ha. Beneath the Tertiary sediments infrabasins contain Devonian, Carboniferous, Permian and Cretaceous sequences.

The Murray Basin lies between two major "geosynclines". These are the Mount Lofty-Olary arc of the Adelaide Geosyncline to the west, and the Tasmanides to the south and west. To the southwest, the Murray Basin is divided from the Otway Basin by the Padthaway Ridge. On its northern flank it is bounded by the Willyama Block and the Cambrian to Devonian Bancannia Trough and the Darling Depression.

STRUCTURE

The major structural feature beneath the Murray Basin are clearly outlined on the Bouguer gravity anomaly map (Fig. 6). The negative anomaly values show sedimentary accumulations and positive anomaly values indicate

BANCANNIA TROUGH

WILLYAMA BLOCK

GEOSYNCLINE

AUSTRALIA

NEW SOUTH WALES

DARLING DEPRESSION

TASMANIDES

TARARRA TROUGH

MENINDEE TROUGH

BLANTYRE BASIN

TROUGH

IVANHOE TROUGH

WENTWORTH TROUGH

RENMARK TROUGH

CANEGRASS LOBE

PARINGA EMBAYMENT

ADELAIDE GEOSYNCLINE

TROUBRIDGE BASIN

PADTHAWAY RIDGE

SOUTHERN OCEAN

VICTORIA

OVENS VALLEY

GRABEN

TASMANIDES

A

B

FIG 6. MURRAY BASIN GRAVITY CONTOUR MAP

KILOMETRES 0 150

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structural highs. Over most of the area the infrabasins are aligned in a northeasterly direction. The Troubridge Basin, Renmark Trough, Tararra Trough and Menindee Trough lie in a nearly straight line which extends into northern New South Wales as the Darling Limeament. The last three are grabens with a dominant northeasterly fault direction. The Blantyre Basin and the Wentworth Trough are nearly parallel to this feature. In the south-eastern part of the area, however, the Ovens Valley Graben trends in a north-northwesterly direction.

STRATIGRAPHY

Devonian: Devonian sediments occur within the deepest portions of the western and northern infrabasins. The sediments can be correlated lithologically with the Lower Devonian, marine Amphitheatre Group and overlying Middle to Upper Devonian, "red bed" Mulga Downs Group, which crop out in the Darling Depression (Bembrick, 1972).

Up to 2 000 m of the fluviatile "red bed" sequence of sandstones and interbedded red siltstones have been intersected in Tararra 1, Blantyre 1, Mount Emu 1, Ivanhoe 1 and Conoble 1. Mount Emu 1 also encountered a considerable thickness of the marine section beneath these sediments. Seismic data indicate that Devonian sediments also occur within the Renmark Trough, up to a thickness of 1 500 m, and in the Canegrass Lobe (Fig. 7, cross section).

Carboniferous: Carboniferous sediments have been intersected from one well only, Blantyre 1, where 103 m of sandstones and conglomerates were encountered.

Permian: The approximate extent of the Permian sediments, together with the thicknesses encountered by wells, is shown on Figure 6. The Permian occurs mainly within the grabens beneath the Murray Basin. In places, however, it extends onto basement highs, especially on the Canegrass Lobe, where Permian sediments fill the lower portions of steep sided valleys (Thornton, 1972a). The thickness of Permian ranges from about 1 000 m in the Renmark Trough and Ovens Valley Graben to less than 100 m in the Blantyre Basin and more than 500 m in the Troubridge Basin.

The Permian sediments are of two different lithological types and ages. These are firstly unnamed Lower Permian marine shales, siltstones, sandstones and conglomerates, and secondly the Upper Permian Oaklands Coal Measures. Marine Permian sediments occur in all the infrabasins, but the coal measures have been encountered only in the Ovens Valley Graben.

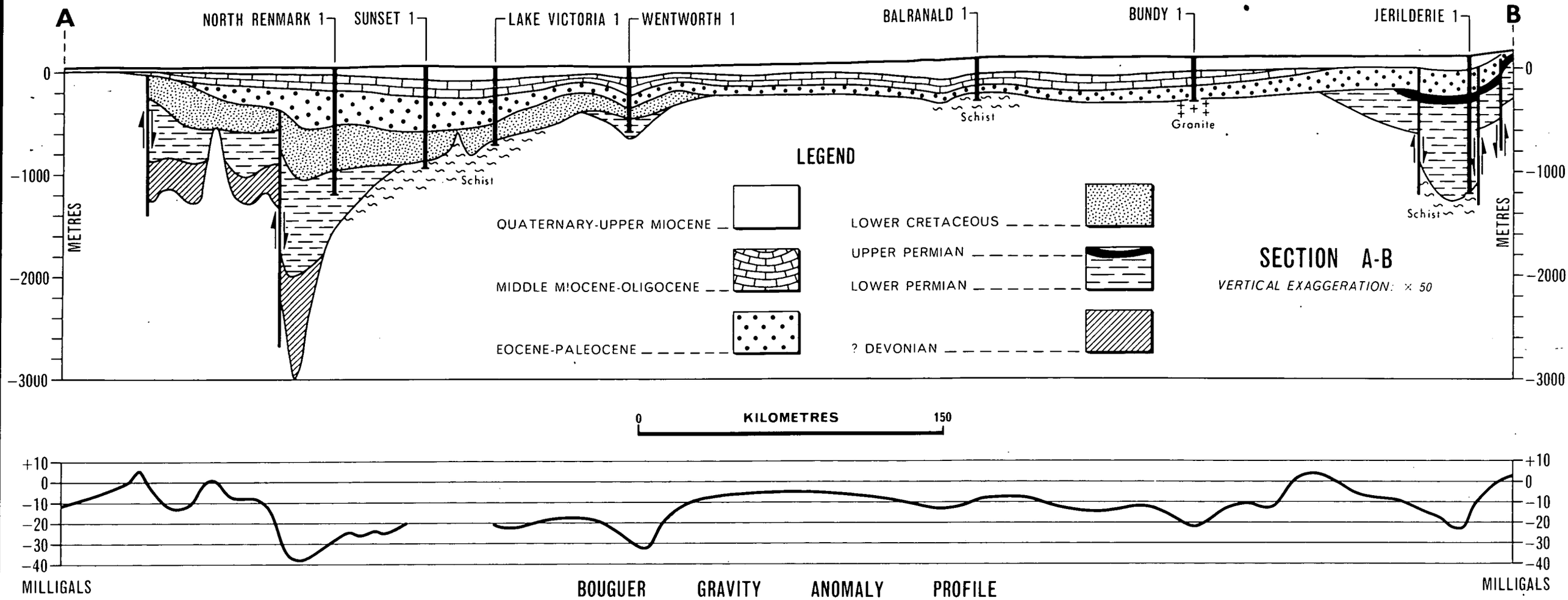
Lower Cretaceous: Lower Cretaceous sediments are preserved beneath the Murray Basin in two known areas, one in the region of the Ivanhoe Trough where they were intersected in Ivanhoe 1 and Conoble 1, the other around Renmark (Evans and Hawkins, 1967). In the latter case, these sediments have been encountered in Tararra 1, Wentworth 1, Lake Victoria 1, and all the wells drilled into the Renmark Trough and Paringa Embayment.

The Cretaceous sequence around Renmark has been named the Monash Formation (Thornton, 1972b) and subdivided into three members. The transgressive marine basal unit, the Pyap Member, consists of unconsolidated, well sorted, quartz sandstone ranging in grain size from medium to very coarse and pebbly. The overlying marine Merreti Member comprises predominantly shale, with minor interbeds of siltstone. The uppermost unit, the Coombool Member, is a freshwater regressive sequence of interbedded sandstone, siltstone and shale.

Tertiary: The Murray Basin sequence comprises a virtually flat lying blanket of freshwater and marine sediments, reaching a thickness of 600 m in the Renmark Trough. The section can be split into three lithological groups: Firstly, predominantly freshwater, Paleocene to Eocene sands, secondly, marine limestones of Oligocene to Miocene age and thirdly, Upper Miocene to Pliocene, marine to freshwater silts and sands.

PETROLEUM PROSPECTS

Devonian: Potential marine source rocks of the Amphitheatre Group are known to occur beneath the Murray Basin in the northern part of the area (encountered in Mt. Emu 1) and may well occur in the Renmark, Tararra and Menindee Troughs. The overlying terrestrial red bed sands have excellent reservoir characteristics. Throughout most of the area, Lower Permian shales would provide a suitable cap rock.



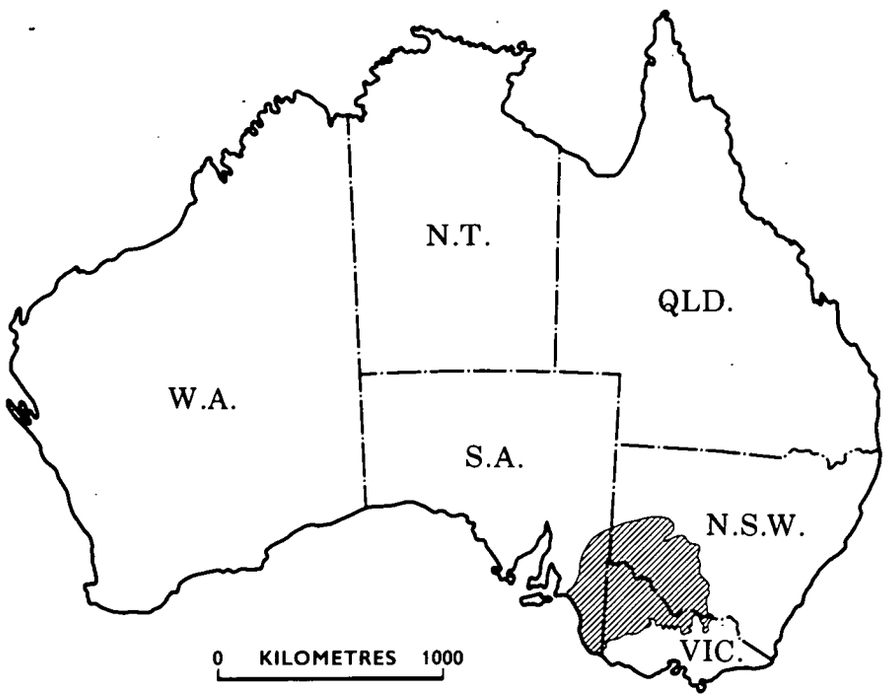


FIG 7.

LOCALITY MAP

MURRAY BASIN

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LEGEND

Murray Basin margin

Bouguer gravity anomaly contour (10 mgal. intervals) 20 10

Exploration well

Thickness of Permian sediments encountered 957 (in metres)

Interpreted Permian intrabasins

INFORMATION SOURCES

Coppin et. al (1971); Bembrick (1972); Johns and Lawrence (1964)

REFERENCE TO BORES

1	TARARRA 1	21	BLANTYRE 1
2	WENTWORTH 1	22	MT. EMU 1
3	LAKE VICTORIA 1	23	IVANHOE 1
4	OLNEY BORE	24	CONOBLE 1
5	NORTH RENMARK 1	25	HOLEY BOX 1
6	MONASH 1	26	DOLMOREVE 1
7	BERRI NORTH 1	27	BOOLIGAL 1 & 2
8	SUNSET 1	28	KILLENDOO 1
9	COMPANY BORE	29	HAY 1
10	BERRI SOUTH 1	30	BUNDY 1
11	MORKALLA 1	31	JERILDERIE 1
12	LOXTON 2	32	URANA 1
13	LOXTON 1	33	BRIMIN 1
14	NADDA 1	34	NORONG 1
15	PINNAROO 1	35	BOORHAMAN 1
16	DONNA 1	36	WANGARATTA NORTH 2
17	KEITH 1	37	CARRARAGARMUNGEE 1
18	WARRAQUIL 1 & 3	38	WANGARATTA SOUTH 3
19	BALRANALD 1	39	LACEBY 2
20	NAMBUCURRA 1	40	MUNDOONA 1
		41	ECHUCA NORTH 1

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Permian: The dominantly argillaceous marine sequence of the Lower Permian might provide a suitable source rock. The sands and conglomerates interbedded with the shales have fair to good porosity and could be good reservoirs. The Upper Permian coal measures may not have been buried deeply enough to have source rock potential.

Lower Cretaceous: The Pyap Member of the Monash Formation has probably the greatest potential as a reservoir. The sands are generally well sorted and unconsolidated with excellent effective porosity and permeability. The predominantly argillaceous Merreti Member is a suitable cap rock.

Tertiary: The porous formations are important freshwater aquifers. This, combined with the shallowness of the section, precludes them as potential hydrocarbon reservoirs.

CONCLUSIONS

Very few wells have been drilled so far in the Murray Basin and the area's potential has not been fully assessed. Potential source rocks and excellent reservoirs are present. Small amounts of gas have been encountered from Permian rocks. The possibility exists of fiding hydrocarbons in anticlinal, fault or wedgeout traps.

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THE PEDIRKA BASIN - Bridget C. Youngs

The Pedirka Basin is a Permian infrabasin lying beneath the western Great Artesian Basin (Wopfner, 1972). Present knowledge suggests that it covers an area of approximately 185 000 km^2. The major portion of the basin lies in the Northern Territory and South Australia, with a small extension into Queensland (Figs. 1 & 2). Six exploration wells have been drilled in the basin and none have found any hydrocarbons.

The present basin limits are defined by outcrops along the Finke River (Wells et al., 1970) and the margins of the Georgina Basin, and by seismic work. The Arunta Block lies at shallow depths in the northern parts of the basin. The southeastern edge of the basin abuts onto the Birdsville Track Ridge and the southwestern margin onto the Musgrave Block. The Permian sediments may be continuous into the Arckaringa Basin to the south (Fig. 1). The Amadeus Basin lies to the northwest.

A major structural division within the basin occurs along the McDills Trend (Fig. 8). This roughly north-south line separates an area of thicker Lower Palaeozoic sediments overlain by relatively thin Permian strata in the west, from an area of thin or absent Lower Palaeozoics and thick Permian sediments to the east. This eastern part is in turn overlain by the thick Mesozoic strata of the western Great Artesian Basin.

The shallow Arunta Block is reflected in the gravity and aeromagnetic patterns in the north of the basin (Figs. 1 & 2). A deep sub-basin occurs in the southwest of the Pedirka Basin; it is believed to be filled with Lower Palaeozoic and possibly Proterozoic sediments.

Figure 8 shows the formations and their approximate thicknesses which were intersected in four of the wells. The Cambrian sediments comrpise a monotonous sequence of marine mudstones and dolomitic shales which are part of the Warburton Basin sequence (Wopfner, 1972). The Ordovician is believed to be widespread beneath the Pedirka Basin and is represented by quartzites in the west and shales in the southeast. Devonian sediments are widespread in the subsurface and are continuous with those in the Amadeus Basin to the northwest. The terrestrial sequence is composed of medium-coarse, cross-bedded sands overlain by a series of conglomerates, sands and shales. The Permian sediments comprise two formations. The lower one is a series of glacial diamictites, sands and shales. The upper formation contains terrestrial sands and shales with the development of coal in the upper layers. The Mesozoic and younger strata belong to the Great Artesian Basin sequence.

The Pedirka Basin reflects the effects of the Alice Springs Orogeny in the northeasterly alignment of structures. The Permian lies at depths of only a few hundred metres in the west and dips to over 2 500 m in the deepest parts which lie towards the eastern margins. Thick coal developments occur in the eastern areas where many structures suitable for trapping hydrocarbons exist (Williams, 1973). There is every possibility that Triassic caprocks could be present in these deeper areas and this fact offers good prospects for future petroleum exploration in the Pedirka Basin.

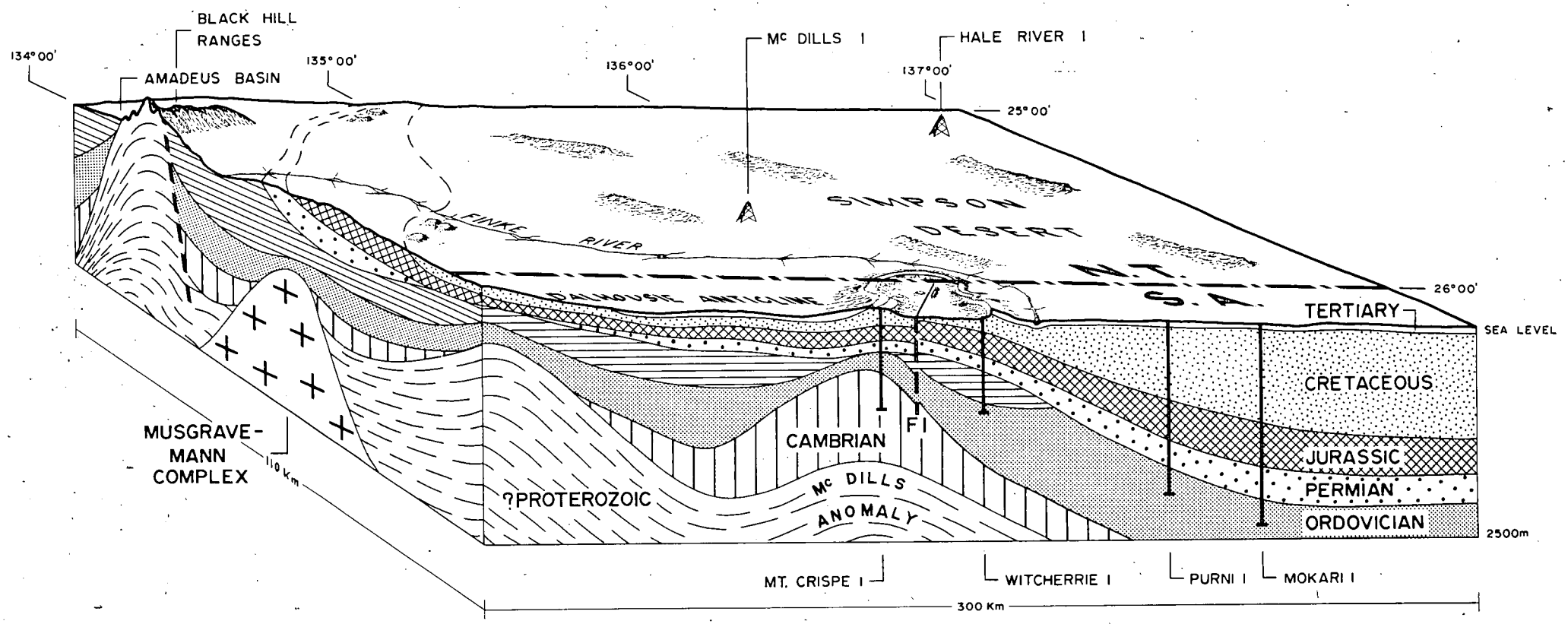

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FIG 8. *Schematic Block Diagram of the Pedirka Basin*

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