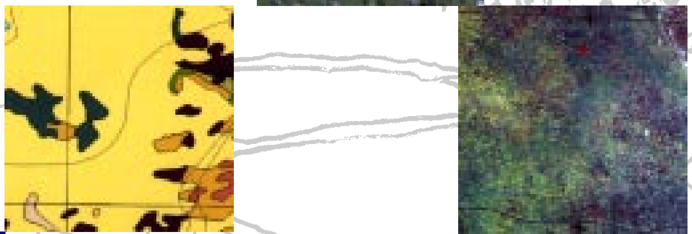
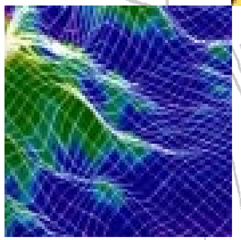
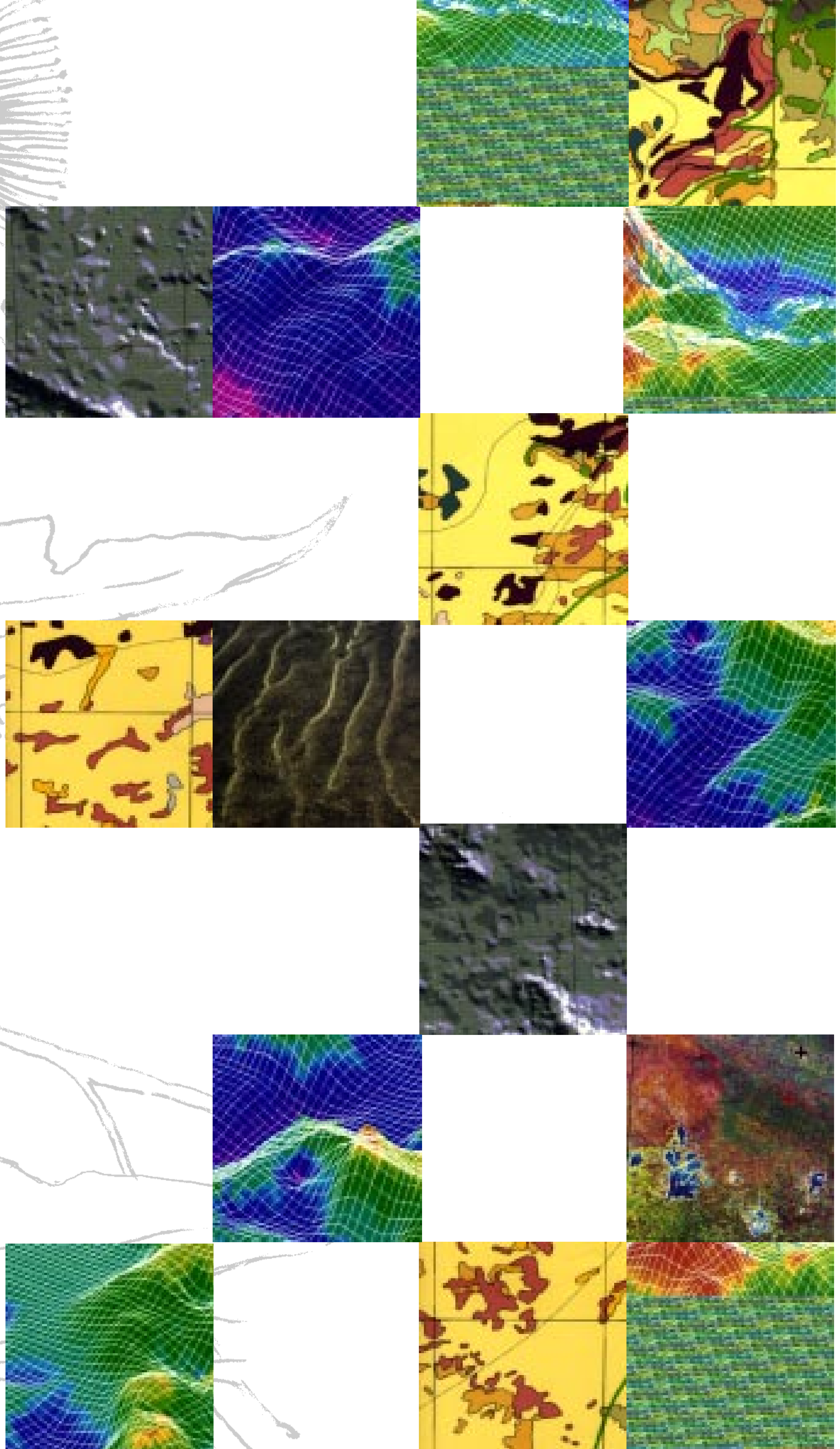
Geological Atlas of the Officer Basin, South Australia.







Edited By J.F. Lindsay

AGSO

Australian Geological Survey Organisation

INTRODUCTION

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The Officer Basin overlies approximately 375 000 square kilometres of the south central part of the Australian craton **(Fig. 1)** (Palfreyman, 1981). It is the third largest of the continent's onshore basins but, in spite of its size, is probably the least known and understood of the intracratonic settings. The lack of knowledge about the basin in large part reflects the poor infrastructure in the region and the general aridity of the environment **(Plate 1).** There are no made roads crossing the basin and only a small number of largely unmaintained single lane tracks **(Plate 1)**. Because the region is extremely dry, there is little run off and almost no stream drainage **(see Plates 1, 9 & 10)**. As a consequence the palaeo-stream network that drained into the Tertiary Eucla Basin to the south remains largely intact **(Plate 8)**.

Because of its inaccessibility and generally inhospitable climate there has been little exploration for either minerals or hydrocarbons in the basin. Consequently, less than 8100 kilometres of seismic data are available and only 30 wells deeper than 500 m have been drilled **(Plate 11)**. In 1993, the Australian Geological Survey Organisation and the Department of Mines and Energy, South Australia renewed research efforts in the basin and gathered seismic data in the central region about which little was known and the northeastern region in a structurally complex area believed to have considerable but untested petroleum potential. These newer seismic surveys have increased knowledge not only of deep basin structure but also, from the associated shothole and water supply drilling, of surficial geology and groundwater occurrence.

This atlas brings together the latest geological ideas, incorporating earlier data **(Plate 11)** gathered in the South Australian part of the basin, in an accessible form. The atlas consists of 30 plates covering a range of topics from topography **(Plates 1 & 2)** and surface geology **(Plate 3 to 7)** to water resources **(Plates 9 & 10)** and potential field data **(Plate 29 & 30)** as well as the architecture of the basin fill **(Plates 14 to 28)**. The atlas has been arranged to present some of the more general features of the basin such as topography, geology, structure and water resources in the earlier plates whilst concentrating on details of the basin fill in later plates.

Figure 1. Distribution of Neoproterozoic and early Palaeozoic intracratonic basins on the Australian craton. Basins initiated in the Neoproterozoic are stippled, those initiated in the early Palaeozoic are hatched, while the cross-hatched areas indicate the distribution of basic volcanics (after Lindsay & others, 1987).

Geologic Setting

The Officer Basin was initiated approximately 800 Ma and contains a Neoproterozoic and early Palaeozoic sedimentary succession **(Fig. 2)**. It is one of a number of basins of similar age and architecture that formed across the Australian craton (e.g. Amadeus, Ngalia, Georgina Basins) (Lindsay & others, 1987) **(Fig. 1)**. There is an accumulating body of evidence which suggests that these basins are all related, probably through some large scale mechanism perhaps resulting from the accretion and ultimate breakup of the Proterozoic supercontinent (e.g. Veevers & McElhinney, 1976; Lindsay & others, 1987; Lindsay, 1993). However, while there is general agreement that the basins are related through some common causal mechanism there is, to date, little agreement as to what that mechanism might be. Suggestions have ranged from extensional settings (Korsch & Lindsay, 1989; Lindsay & Korsch, 1989, 1991; Lindsay & others 1987) to compressional and flexural settings (Lambeck, 1983; Ding & others, 1992).

Basin Architecture

The overall form of the Officer Basin is clearly defined by potential field data **(Plate 29 & 30)**, especially total magnetic intensity images. Like the Amadeus, Georgina and Ngalia Basins the Officer Basin **(Fig. 1)** has one sharply defined margin, the northern margin **(Plate 12)**, which is closely paralleled by an arcuate series of deep sub-basins which shallow gradually toward the opposite margin to merge with a broad shallow platform, the Murnaroo Platform **(Plates 4 & 30)** (Leven & Lindsay, 1992). Recently acquired deep seismic data show the north central margin of the basin to be a homocline. However, total magnetic intensity data **(Plate 30)** suggest that the structure of the northern margin is variable and complex along its length (Leven & Lindsay, 1992). Two sub-basins: the Birksgate Sub-basin to the west and the Munyarai Trough to the east appear to be separated by a well defined magnetic and gravitational ridge called the Nurrai Ridge (Hibburt, 1990). Again, however, seismic data gathered during the present study **(see Plate 11)** suggests that the Nurrai Ridge is not part of the basin architecture but relates to a more deeply seated structure within the crust **(see Plates 29 & 30).** The Birksgate Sub-basin which reaches a depth of approximately 5 km is connected to the Murnaroo Platform to the south by a gently dipping (0.3^{o}) ramp. The sedimentary succession over the Murnaroo Platform gradually thins to the south ultimately terminating against the Mesoproterozoic or older Coompana Block. The Munyarai Trough, which is almost 10 km deep, ramps southward more steeply terminating against a major ridge, the Ammaroodinna Ridge, (Stainton & others, 1988) which separates it from the shallow elongate northeast-southwest-trending Manya Trough. Farther south from the Manya Trough the basin thins onto the edge of the Gawler Craton, with a series of troughs and ridges that parallel the craton's boundary (the Nawa Ridge and the Tallaringa Trough). The Karari Fault essentially separates the Officer Basin from the Gawler Craton, although the latter was onlapped in early Cambrian time.

The crust beneath the Officer Basin and for some distance north beneath the Musgrave Block is approximately 42 km thick **(Plate 5)** (Lindsay & Leven, in prep.). North-dipping linear events interpreted as major faults pervade the crust but are erosionally truncated structures that simply terminate against the Neoproterozoic sediments of the Officer Basin. A proportion of the faults have, however, been reactivated especially those along the northern margin of the basin and in some areas along the southern margin of the deep sub-basins and along the Ammaroodinna Ridge to the south.

The northern margin of the basin is a monoclinal upturn resulting from the rotation or roll back of the older sedimentary basin fill in front of a southerly directed, imbricate basement thrust wedge produced by a major local reactivation during the Alice Springs Orogeny of some of the earlier structures **(Plate 5)**. The growth of structures, such as the Ammaroodinna Ridge along the southern margin of the sub-basins, can be linked by their onlapping relationships to localised movement on major faults within the crust during compressional events.

Basin Fill Architecture

The Officer Basin is a complex, polyphase, stacked basin which was influenced by a number of tectonic events of varying magnitude (Lindsay & Korsch, 1989, 1991; Shaw; 1991; Lindsay & Leven, in prep.). The sedimentary fill of the basin can be subdivided into six major packages or megasequences (M1 to M6, **Fig. 2**) each bounded by well defined, tectonically enhanced, erosional sequence boundaries. Each megasequence represents the accumulation of sediments during a major subsidence event such that the sequence boundaries imaged seismically within the megasequences all have distinctive stacking patterns giving some indication as to their tectonic origins as well as sealevel controls (Lindsay & Leven, in prep.). Megasequences M1, M2 and M4 all show evidence suggesting that tectonic subsidence during these time intervals was controlled by thermal decay. The stacking of depositional sequences within megasequences M2 and M4 in particular show patterns typical of thermal decay with sequence boundaries becoming more closely spaced with time as in equivalent intervals in the Amadeus Basin (Lindsay & Korsch, 1991; Lindsay & others, 1993). Sequences M3, M5 and M6 display sequence stacking patterns with closely spaced reflectors more typical of compressional events. M3 is the product of the Petermann Ranges Orogeny which influenced both the Officer Basin and the southwestern margin of the Amadeus Basin whilst M5 and M6 were deposited in foreland basin settings in response to the Delamerian and Alice Springs Orogenies.

Sequence stacking patterns within megasequence M1 suggest that the earliest Willouran (c. 800-760 Ma) units of basin fill (Alinya Formation and Pindyin Sandstone) are the product of broad regional subsidence **(Plate 16)**. They are widespread, very uniform in thickness and are onlapped by the younger (mostly Marinoan, c. 650-540 Ma) units deposited in the main sub-basins. The depositional pattern is very similar to the equivalent time interval in the Amadeus Basin (Heavitree Quartzite and Bitter Springs Formation) and the Ngalia Basin (Vaughan Springs Quartzite and Albinia Formation) suggesting broad regional subsidence perhaps relating to the "superbasin" phase proposed by Walter & others (1993). The top of this megasequence is defined by a major erosion surface **(Plate 17)** which may represent a time period of close to 100 m.y. (Gravestock & Lindsay, 1994). Again a similar regional erosion surface is found above the Bitter Springs Formation in the Amadeus Basin, however, it appears to represent a considerably shorter time interval as the Sturtian glacial interval is well represented in the Amadeus Basin (Lindsay, 1989). The record of Sturtian glacial deposition is confined to the most eastern part of the Officer Basin.

The depositional setting changed abruptly above the erosion surface at the top of megasequence M1. Stacking patterns within the sedimentary rocks of megasequence M2 are very different **(Plates 19 to 23)**. The earliest sequence boundaries are widely spaced but they become more frequent towards the top of the interval. Sequence boundaries are no longer simply parallel planar surfaces but show evidence of northward progradation and individual sequences show evidence of complex internal structure. These complexities result from the development of major sub-basins, the Birksgate Sub-basin and the Munyarai Trough **(Plate 19)**. The Officer Basin was thus no longer part of the regionally subsiding superbasin but had become decoupled with rapidly subsiding sub-basins whose mechanics were defined by more local conditions.

Megasequence M3 **(Plates 24 & 25)** which includes the upper Ungoolya Group is the product of the Petermann Ranges Orogeny, a compressional event which influenced both the Officer Basin and the southwestern margin of the Amadeus Basin. The upper Ungoolya Group rests on a very distinctive deeply dissected erosion surface which is transected by deeply incised canyons **(Plate 24)** above which there is an abrupt change in sequence architecture and depositional style. Seismic reflections from sequence boundaries are widely spaced below the canyon surface but are very closely spaced and close to seismic resolution above the surface. The canyon surface probably reflects the onset of the Petermann Ranges Orogeny and it seems probable that the overlying megasequence was deposited in a foreland basin setting **(Fig. 2)**.

Megasequence M4 includes all of the Cambrian units of the Officer Basin (Gravestock & Hibburt, 1991) **(Plate 27)**. The Precambrian-Cambrian boundary surface **(Plate 26)** at its base is a prominent erosional surface resulting from uplift associated with the Petermann Ranges Orogeny. Following the orogeny, the basin entered a new evolutionary phase. During the early Marinoan subsidence was relatively rapid within the confines of the major sub-basins. However, stacking patterns within megasequence M4 suggest that during the Cambrian the subsidence of the eastern Officer Basin had slowed considerably but had become much more regional such that sediments draped the Ammaroodinna Ridge and other prominent structural highs **(Plate 27)**. The broad regional subsidence during the Cambrian and the foundering of the basin's southern margin may simply relate to strain release at the end of the Petermann Ranges Orogeny however, evidence from the Amadeus Basin to the north suggests that the crust had been thinned in central Australia perhaps in response to extension (Lindsay & Korsch, 1989, 1991). Locally, however, in the Tallaringa and Manya Troughs subsidence was rapid and more than 1700 m of sediment accumulated. The Petermann Ranges Orogeny resulted in uplift of the Musgrave Block during the latest Neoproterozoic such that, by Cambrian time, the Officer and Amadeus Basins had become separate entities.

Megasequences M5 and M6 were deposited in foreland basin settings that evolved in response to the Delamerian and Alice Springs Orogenies respectively. In the early stages of the Delamerian Orogeny stream flow along the axis of the foreland basin resulted in erosion that reached at least locally as deep as the upper Neoproterozoic part of the succession. South of the homocline, Devonian and Ordovician units of these megasequences are structurally concordant and were deposited in shallow foreland basin settings. Ordovician siliciclastics (megasequence M5) form part of a thick deltaic to marine wedge (Webby, 1978) which disconformably overlies the Cambrian. The thickest sections are in the Munyarai and Manya Troughs and in the Marla Overthrust Zone. Devonian fossiliferous lacustrine sediments and evaporitic redbeds (megasequence M6), which are confined to the Munyarai Trough, disconformably overlie the Ordovician (Gravestock & Lindsay, 1994). The volumes of sediment preserved in the foreland basin suggest extensive erosion **(Plate 28)** but not to the same scale as that observed in the Amadeus Basin where locally more than half the basin fill was derived from the erosion of the homocline during the Alice Springs Orogeny (Lindsay & Korsch, 1989, 1991; Jones, 1972, 1991).

As in the Amadeus Basin (Lindsay & Korsch, 1989) the Alice Springs Orogeny effectively terminated sediment accumulation in the Officer Basin. The basin has remained a relatively stable part of the crust since the middle Palaeozoic. Late Carboniferous and Early Permian glaciomarine and glaciofluvial sediments extend west from the Arckaringa Basin into the eastern Munyarai Trough and throughout the Manya and Tallaringa Troughs. Maximum sediment thickness is 400 m in the Wintinna Trough which connects the eastern Manya and Boorthanna Troughs. Late Jurassic to Early Cretaceous fluvial and marine deposits of the Eromanga Basin are similarly thin and confined to the most easterly regions. Late Cretaceous shoreward extensions of the Bight Basin are confined to the region south of the Ooldea Sand Range. Subsidence of the southern margin of the continent, as a response to the separation of Australia and Antarctica, led to deposition of Tertiary carbonates of the Eucla Basin that now form the Nullarbor Plain. Well preserved Eocene stream channels cross the main part of the Officer Basin and locally there are related fan delta and beach dune deposits **(see Plates 6 to 8)**.

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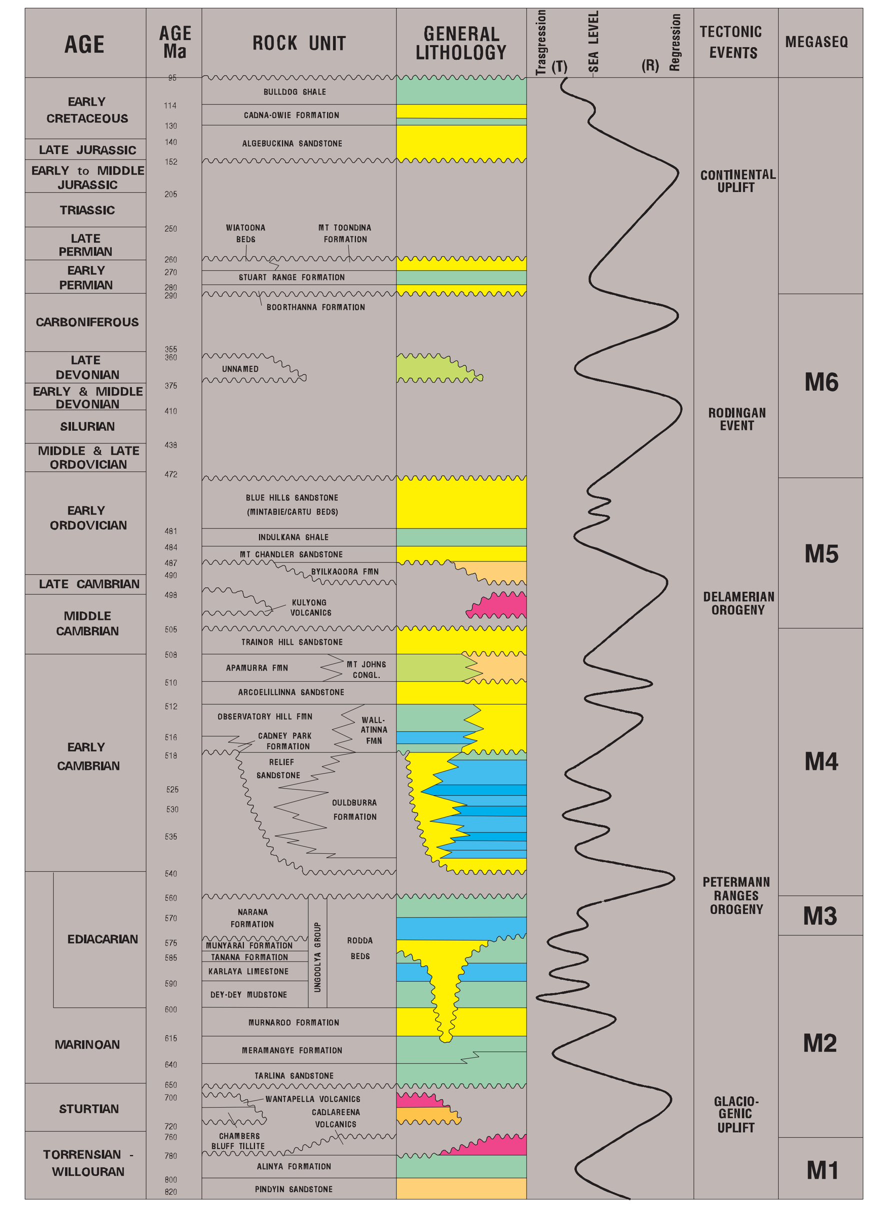

Figure 2. Simplified stratigraphy for the central and eastern Officer Basin (adapted from Gravestock & Lindsay, 1994). Megasequences are labelled M1 to M6.

Topographic and Surface Elevation Maps

G. W. Krieg

Landscape and climate

The Officer Basin region is dominated by the Great Victoria Desert, a major aeolian dunefield which conceals most of the Basin fill and extends onto the Musgrave Block **(Plate 3)**. It is part of a continent-scale dune swirl that forms one of the large sand deserts of the world. Further east and north it forms the Simpson Desert. This Late Pleistocene to Holocene dunefield was established perhaps 15 000 to 18 000 yrs BP during the cold, arid conditions of the last glacial maximum. It is now fixed by sparse vegetation under hot, semi-arid to arid conditions.

The region has a hot desert climate. The summer (January) and winter (July) average maxima /minima temperatures for Maralinga are 33°C/16.3°C and 17°C/6.7°C respectively. Further into the desert temperature variation is more extreme as summer daytime maxima can approach 50°C and winter night time minima sub-zero. Rainfall is low (150-200 mm p.a.) and unreliable, with no distinct seasonal pattern; evaporation is high (3600 mm p.a.). Under such climatic conditions the natural vegetation is sparse, low and sclerophyllic. Typically, a 3-4 m high open woodland of mulga and mallee is underlain by lower shrubby cover such as saltbush, bullock bush and sandhill wattle, and a ground cover of spinifex, bindyi, grasses and herbs. Plant differentiation, controlled by substrate type and water availability, is notable throughout the region. Mulga prefers the deep sand of the central dunefield and grows more thickly where rainfall run-off collects along the axes of the dune corridors. Spinifex forms an adjacent zone on the lower dune flanks, and sparser mulga, mallee and occasional large marble gums are found nearer the crest. In calcareous and gypsiferous areas, such as along playa lake systems, mallee and particularly the desert oak are prevalent.

Dune field morphology shows a dune-to-swale relief of up to 25 m but more usually 7-12 m. Interdunal corridors range from about 400 m to 1200 m in width except for the complex multiple-crested dunes where crest separation may be no more than 100m. Dune field material consists of red-brown very fine clayey quartz sand forming the floor of the interdunal corridors, passing up to paler, orange brown fine quartz sand on the dune slopes and crests. Occasionally, weak carbonate palaeosols are present as a diffuse rubbly layer within the dunes. The dunefield crests are largely fixed by desert vegetation but may become mobile after major disturbance such as bulldozer earth work.

In the north of the study area a line of scattered hills and low ridges extends eastwards from the South Australia/Western Australia border to the Stuart Highway. Here, the Officer Basin strata have been folded and faulted against the Musgrave Block leaving the more resistant rocks standing above the dunes. The hills are composed of sandstone and quartzite of the lower Officer Basin succession, and of granite and gneiss of the Birksgate Complex. The sandstone/quartzite hills and ridges are generally less than 100 m higher than the dunefield except in the eastern end of the Basin where the regional synclinal closure is structurally complicated by the Marla Overthrust Zone. Here the Mount Johns and Indulkana Ranges rise 200m above the surrounding plains. The hills formed of Birksgate Complex are commonly higher, occurring as red, inselbergs rising 250 m or more above their surroundings.

In the southern and eastern region of the study area other physiographic features are dominant. The Nullarbor Plain and Ooldea Range represent an emergent, Miocene limestone sea bed, and associated beach dune complex. The adjacent playa lake system (Lakes Wyola, Maurice and Dey Dey) are thought to be important outlets for Officer Basin ground water **(Plate 9)**. To the northeast the Carnadinna Surface (Benbow, 1993) is a very subdued, slightly elevated and dissected, former land surface of ferruginous gravel derived from the ferruginised blanket of basal Eromanga Basin sediments. Further east, is the Stuart Range, an elevated, strongly dissected plateau of Tertiary silcrete and associated ferruginous materials, overlying Eromanga Basin deposits.

Crossing the region from north to south there is a system of elongate topographic depressions that broadly follow the regional surface-elevation gradient; base-level elevation decreases from 500m AHD along the margin of the Musgrave Block to 200m AHD on the Nullarbor Plain. The system is a relict palaeoriver network that drained into the southern Eocene and Miocene seas or associated coastal backwaters. The palaeovalleys are generally broad, low-relief, dune-blanketed depressions that may locally follow underlying basin structure. These valleys contrast with those of the Simpson Desert, for example, and may be structurally significant. In places, these valleys and their small local tributaries expose a few metres of the uppermost, subhorizontal Officer Basin units. Some of the larger, broader palaeovalleys are marked by lines of claypans or saline/gypsum playas and fresh water (lacustrine) carbonate sheets. Of these, the notable Serpentine Lakes palaeovalley has incised up to 20 m into the Officer Basin sediments and has developed a terminal fan where it emerges through the Ooldea Range.

In contrast to the palaeodrainage, modern drainage is restricted to the north of the study area and consists of local gutters and small gullies around the hills. The one exception is the Officer Creek which extends some 60 km into the dune field but flows only after continuous heavy rain. As a consequence of the low rainfall, and isolation from the continent's high rainfall regions (unlike the Simpson Desert), there are no major active rivers in the Officer Basin region and permanent to semipermanent surface water is non-existent.

Access and land tenures

The two arterial access routes to the Officer Basin region are the Stuart Highway (National Route 87) on the eastern margin and the Trans Australian Railway on the southern margin. Take-off points into the desert are Coober Pedy, Cadney Park, Marla and Indulkana in the east, and Watson and Cook in the south. Roads and tracks are unsealed, and vary in quality from good to poor, at various places and times depending on the amount of recent vehicle use and rainfall They are best regarded as four-wheel-drive tracks although conventional vehicles are adequate for the better sections. For transporting heavy equipment, bulk supplies and water tankers, the railway is a useful access route in the south.

A number of different land tenures affect the Officer Basin region of South Australia. The largest areas are held under Aboriginal Title and are designated Pitjantjatjara Aboriginal Land and Maralinga Tjarutja Aboriginal Land. Access to these Lands is through negotiation with the appropriate Aboriginal authority, and assistance to the mineral industry with this matter is available from MESA. Two large conservation parks, the Unnamed Conservation Park and the Tallaringa Conservation Park, occur in the west and east of the region respectively. These are administered by the South Australian Department of Environment and Natural Resources. Smaller restricted areas around Emu and Maralinga, (former atomic bomb testing sites) are controlled by the Commonwealth Department of Primary Industries and Energy. Along the eastern margin of the study area, there is a patchwork of pastoral leases which run cattle in the north and sheep in the south.

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Geological Atlas of the Officer Basin, South Australia

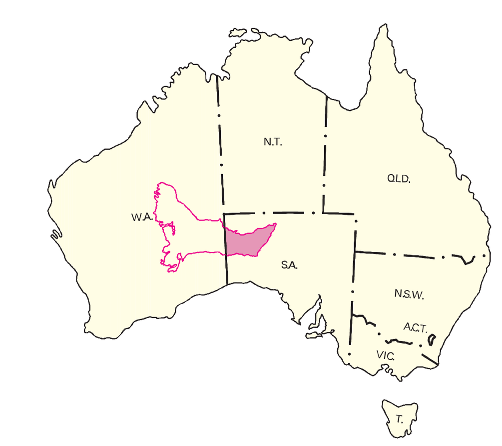
Contents

OFFICER BASIN

SOUTH AUSTRALIA

Topographic Map

STUDY AREA



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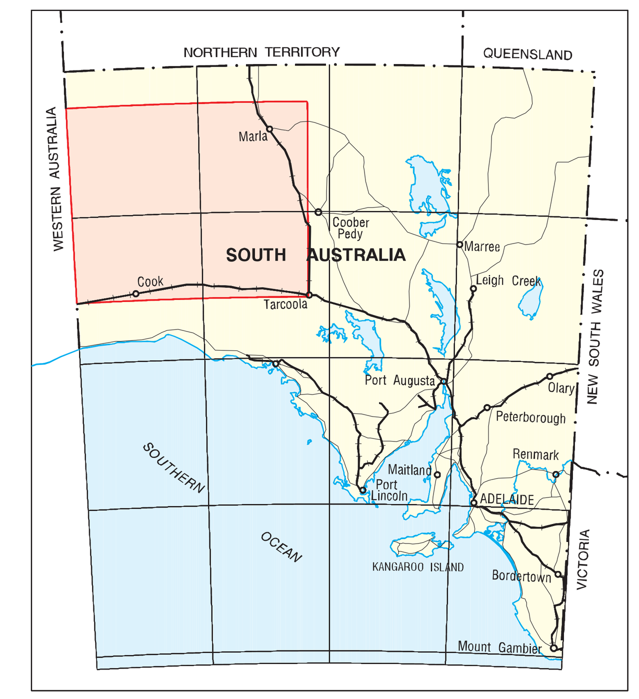

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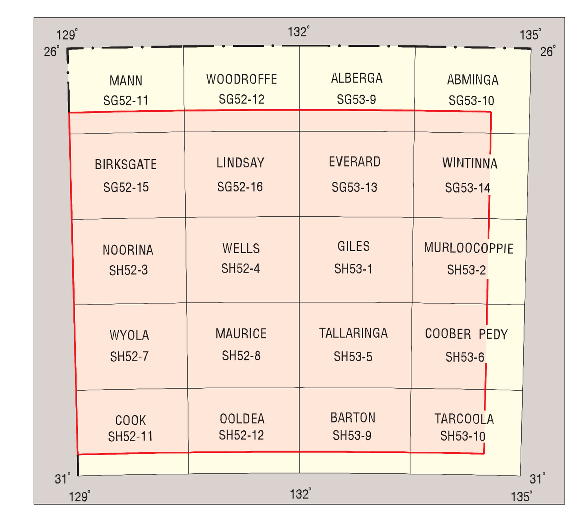

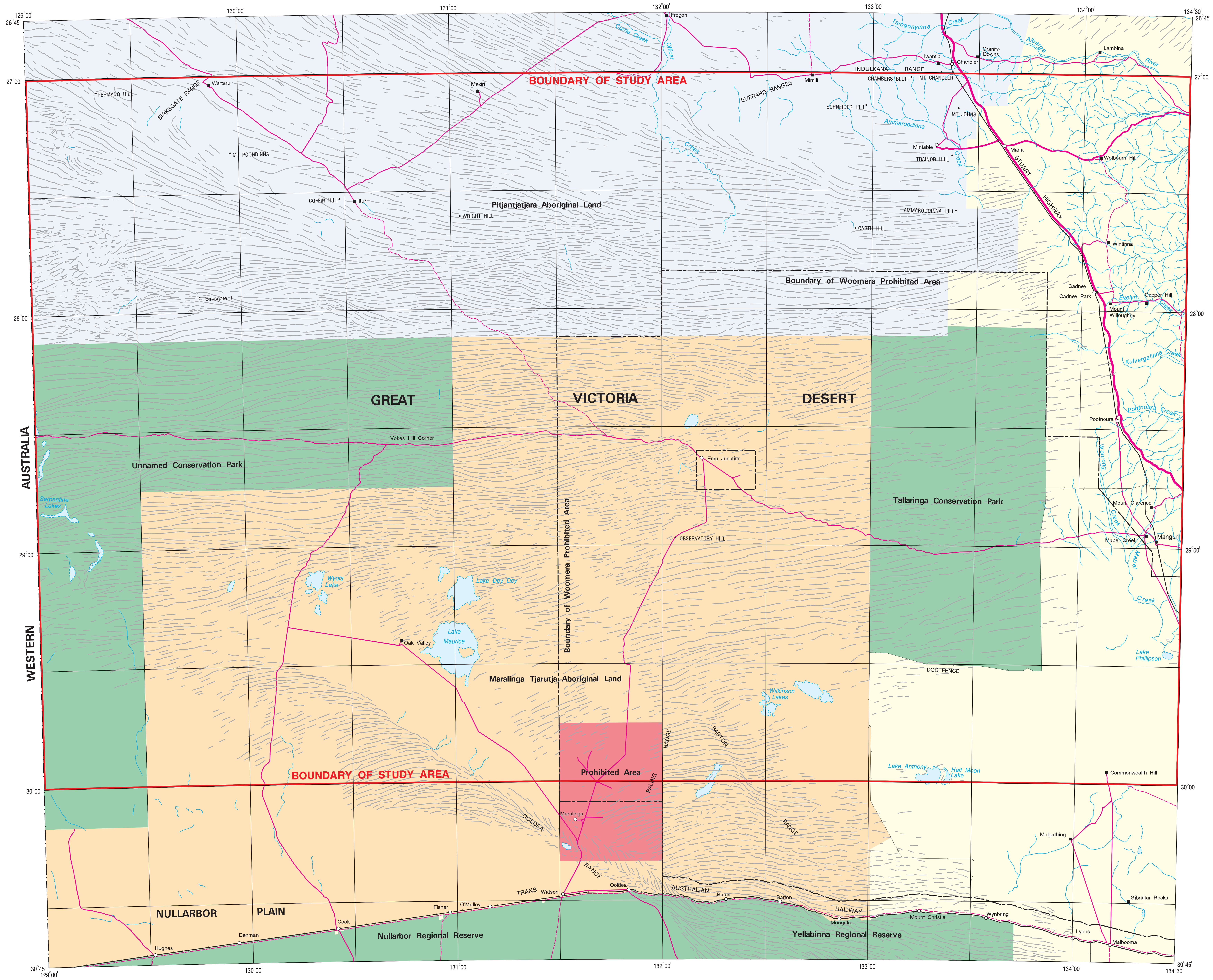

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Standard Parallels 27°15'S 30°15'S.
Central Meridian 132°E.

REFERENCE

- HILL
- SAND DUNE
- PLAYA LAKE
- EPHEMERAL STREAM
- HIGHWAY
- SECONDARY ROAD
- MINOR ROAD
- TRACK
- DOG FENCE
- RAILWAY
- TOWN OR LOCALITY
- ABORIGINAL COMMUNITY; HOMESTEAD
- EXPLORATION DRILLHOLE

NGMA

Product of the National Geoscience Mapping Accord

Topographic detail based on information supplied by Department of Environment and Natural Resources, South Australia.

Parks and Reserves supplied by Department of Housing and Urban Development, South Australia.

Cartography by the Mapping Section, Drafting Services Branch, Department of Mines and Energy, 191 Greenhill Road, Parkside 5063, South Australia.

Map generated from digital data using Arc/Info software.

It is recommended that this map be referred to as:
MESA, 1995 -
Topographic Map (1:1 000 000)
In: Lindsay,J.F. (editor), Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy, Adelaide.

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MINES AND ENERGY SOUTH AUSTRALIA

GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 1

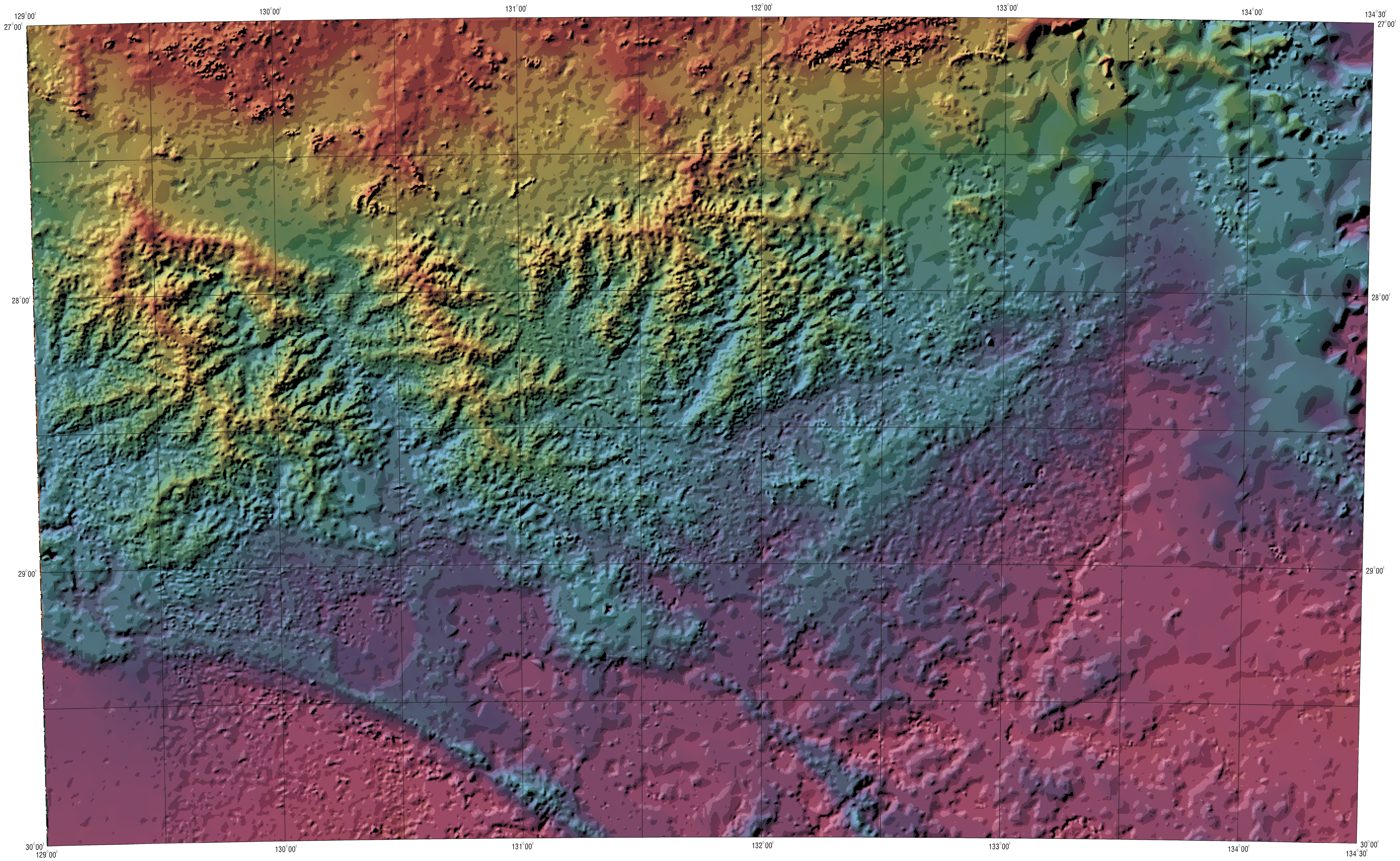
Topographic Map

1995

OFFICER BASIN

SOUTH AUSTRALIA

Surface Elevation Map



Lambert Conformal Conic Projection

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Central Meridian 132°E.

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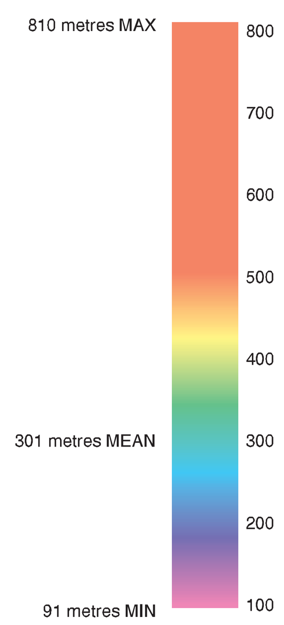
KILOMETRES 20 0 20 40 60 80 100 KILOMETRES

The elevation model was generated from data supplied by AUSLIG as part of the TOPO-250K digital data package. Within the model area, 157 000 spot elevations were triangulated using the Delaunay triangulation method. The triangulated network was gridded to a cell size of 400 metres using bivariate quintic interpolation.

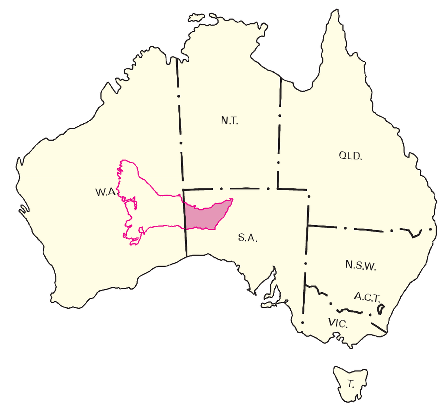
The grid is shaded using a traditional linear stretch of the spectrum colours, reduced to 60% saturation. Grid cells below the mean elevation minus 2 standard deviations are coloured violet; those above the mean plus 2 standard deviations are coloured red. Grid cells that fall within this range are stretched linearly within the red to violet spectrum.

The hillshading was generated from the elevation model with a light source at altitude 45° and azimuth 315°.
Grid statistics: Maximum Z 810m, minimum Z 91m, mean Z 301m, standard deviation Z 103m.



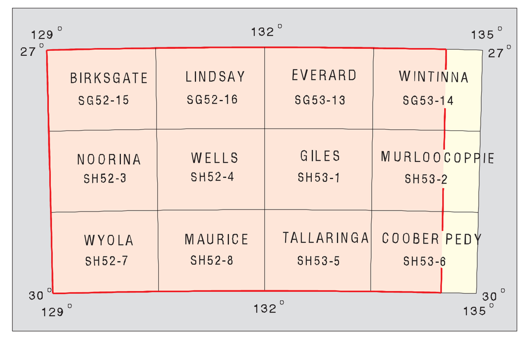
ELEVATION SCALE
metres AHD

STUDY AREA



LOCALITY PLAN

INDEX TO 1:250 000 MAPS



Elevation model and perspective view generated by the GIS Support Group, Drafting Services Branch, Department of Mines and Energy, South Australia, from digital data using Arc/Info software.

Cartography by the Mapping Section, Drafting Services Branch, Department of Mines and Energy, 191 Greenhill Road, Parkside 5063, South Australia.

It is recommended that this map be referred to as
MESA, 1995 -
Surface Elevation Map (1:1 000 000)
In: Lindsay,J.F. (editor), Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy, Adelaide.

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MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

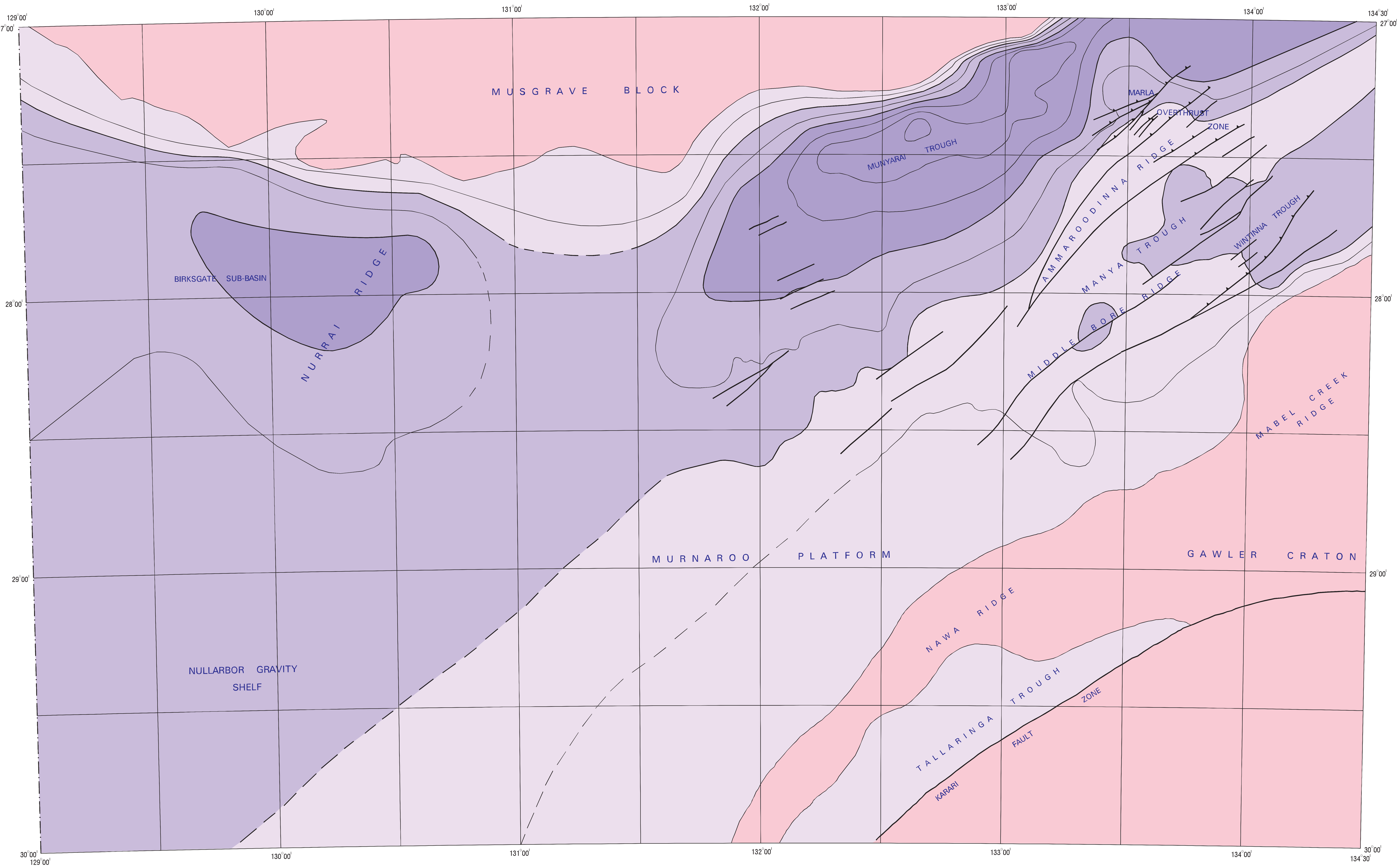
PLATE 2
Surface Elevation Map
1995

OFFICER BASIN

SOUTH AUSTRALIA

Tectonic Elements Map

by D.Gravestock, J.F.Lindsay



Lambert Conformal Conic Projection

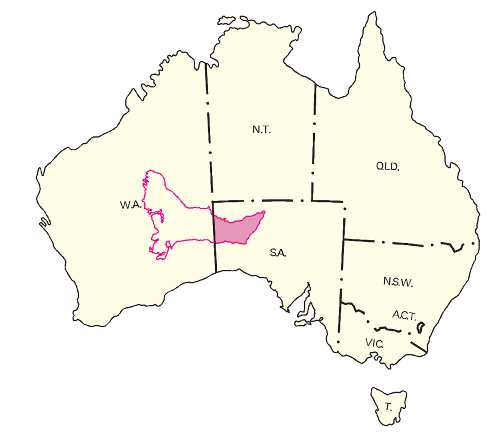
Standard Parallels 27°15'S 30°15'S.

Central Meridian 132°E.

SCALE 1 : 1 000 000

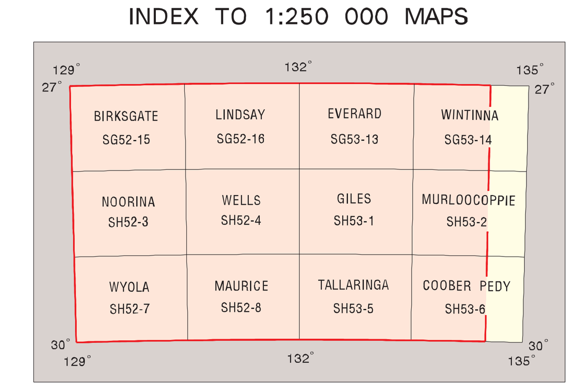
KILOMETRES 20 0 20 40 60 80 100 KILOMETRES

STUDY AREA



LOCALITY PLAN

INDEX TO 1:250 000 MAPS



REFERENCE

Fault

Thrust fault. Triangle on older rocks

Contour

Crystalline basement

TWT basement

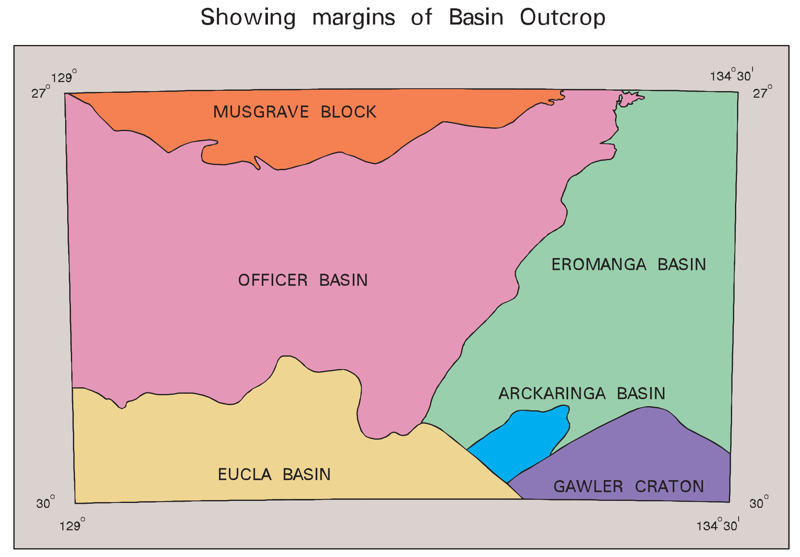
0 - 1000ms

1000 - 2000ms

>2000ms

GEOLOGICAL PROVINCES

Showing margins of Basin Outcrop



Cartography by the Mapping Section, Drafting Services Branch, Department of Mines and Energy, 191 Greenhill Road, Parkside 5063, South Australia.

Map generated from digital data using Arc/Info software.

It is recommended that this map be referred to as:
Gravestock,D.I.,Lindsay,J.F., 1995 -
Tectonic Elements Map (1:1 000 000)
In: Lindsay,J.F. (editor), Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy, Adelaide.

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GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 3

Tectonic Elements Map

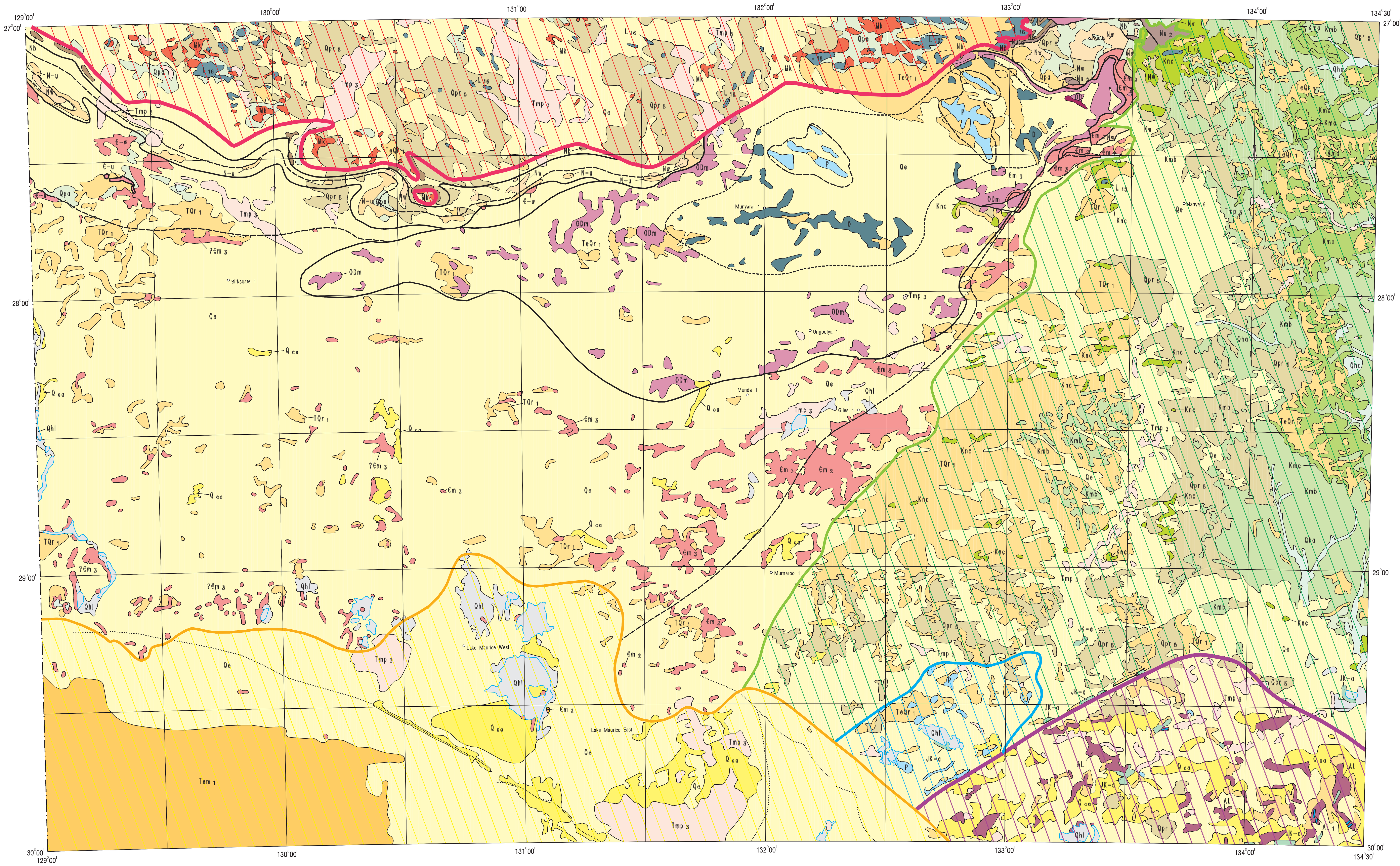
1995

OFFICER BASIN

SOUTH AUSTRALIA

Geological Map

By G.W.Krieg



Lambert Conformal Conic Projection

Standard Parallels 27°15'S 30°15'S.

Central Meridian 132°E.

SCALE 1 : 1 000 000

KILOMETRES 20 0 20 40 60 80 100 KILOMETRES

REFERENCE

CAINOZOIC	QUATERNARY	Qha	Stream alluvium.
		Qhl	Lacustrine and aeolian sediments associated with playas and lakes.
		Qe	Aeolian sand of inland dune fields and associated older fluvial sediments.
		Qpr5	Shallow, red, sandy clay.
		Qpa	Gravelly and sandy clay of piedmont slopes and alluvial plains, commonly gypcreted or calcreted.
		Qca	Undifferentiated calcrete.
	TERTIARY	TQr1	Ferruginous gravel and sand; dissected ferruginous duricrusts.
		Tmp3	GARFORD FORMATION, MANGATITJA LIMESTONE (Eucla Basin palaeodrainage): Lacustrine dolomite, clay, silt and sand.
		TeQr1	Undifferentiated Early Tertiary to Plio-Pleistocene alluvial,colluvial and residual clastics, commonly silicified or ferruginised.
		Tem1	NULLARBOR LIMESTONE (Eucla Basin): Marine limestone.
		(dotted line)	Eocene coastal ridges.
MESOZOIC	CRETACEOUS	Kmo	OODNADATTA FORMATION: Marine mudstone.
		Kmc	COORIKIANA SANDSTONE: Marginal marine sandstone and mudstone.
		Kmb	BULLDOG SHALE: Marine mudstone.
		Knc	CADNA-OWIE FORMATION: Transitional, non marine to marine sandstone and siltstone.
	JURASSIC	JK-a	ALGEBUCKINA SANDSTONE: Fluvial sandstone.
PALAEOZOIC	PERMIAN	P	BOORTHANNA FORMATION, STUART RANGE FORMATION, MT TOONDINA FORMATION (Arckaringa Basin): Glaciomarine and fluvioglacial sediments, including diamictite. WAITOONA BEDS: Alluvial fan sandstone and conglomerate.
	MIDDLE DEVONIAN-?CARBONIFEROUS	D	Labile sandstone and interbedded mudstones. Fish remains.
	ORDOVICIAN-?DEVONIAN	OD	MINTABIE BEDS: Fluviodeltaic, arkosic and lithic sandstone and siltstone.
		ODm	"MUNDA SEQUENCE", including MOUNT CHANDLER SANDSTONE: Shallow marine to deltaic sandstone, siltstone and shale.
	CAMBRIAN (MARLA GROUP)	€m3	TRAINOR HILL SANDSTONE: Deltaic sandstone, siltstone and shale: MT JOHNS CONGLOMERATE: Fan-delta conglomerate and sandstone.
		€-u	KULYONG VOLCANICS: Basalt.
		€-w	WIRRILDAR BEDS: Micaceous mudstone, calcareous siltstone, dolomite, arkosic sandstone.
		€m2	ARCOEILLINNA SANDSTONE: Fluviolacustrine and aeolian lithic sandstone; OBSERVATORY HILL FORMATION; Playa siltstone, shale, carbonate and chert; WALLATINNA FORMATION: Fluvial arkose and fanglomerate.
NEOPROTEROZOIC	ADELAIDEAN	N-u	PUNKERRI SANDSTONE: Shallow marine sandstone, quartzite and siltstone with possible Ediacaran metazoan fauna.
		Nw	WILPENA GROUP EQUIVALENT: Dominantly marine shale, sandstone and limestone. Includes WRIGHT HILL BEDS, UNGOOLYA GROUP and RODDA BEDS.
		Nu2	WANTAPELLA VOLCANICS (tholeitic basalt). UMBERATANA GROUP: CHAMBERS BLUFF TILLITE: Glacigenic diamictite, sandstone, siltstone, quartzite.
		Nb / No	CALLANNA/BURRA GROUPS, ALINYA BEDS: Tidal, sabka and aeolian anhydritic siltstone, sandstone, shale, dolomite and minor chert. PINDYIN SANDSTONE: Tidal and aeolian sandstone and quartzite. CADLAREENA VOLCANICS: Basalt. (subsurface only).
MESO-PROTEROZOIC		Mk	KULGERA SUITE: Granitoids of Musgravian Orogeny.
PALAEO-PROTEROZOIC		L16 / L15	BIRKSGATE COMPLEX and WARTARU GNEISS (L16), Musgrave Block: Metasediments, gneiss, granulite. Ammaroodinna and Yoolperlunna Inliers (L15): Metasedimants, gneiss, calcsilicate.
ARCHAEAN-PALAEOPROTEROZOIC		AL	MULGATHING COMPLEX (northern Gawler Craton): Metasedimentary and granitic gneiss, amphibolite (including pillow basalt, pyroxenite, komatite)
		AL1	Iron formation.

FAULT ....

GEOLOGICAL BOUNDARY ....

INTERPRETED SUBCROP BOUNDARIES WITHIN OFFICER BASIN:

UNCONFORMABLE ....

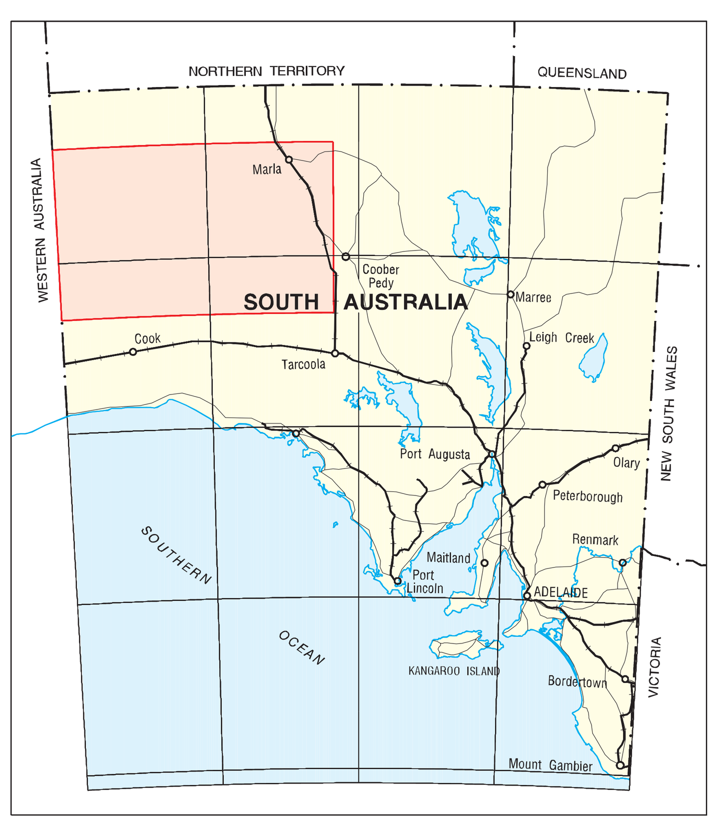
CONFORMABLE ....

UNCERTAIN ....

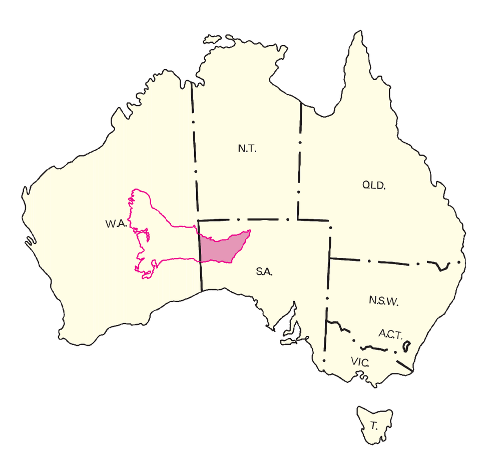
PLAYA LAKE ....

EXPLORATION DRILLHOLE ....

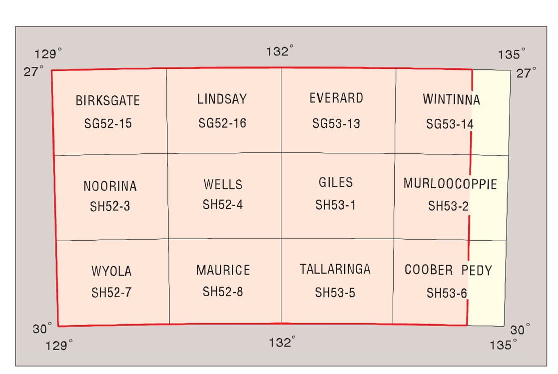
LOCALITY PLAN



STUDY AREA



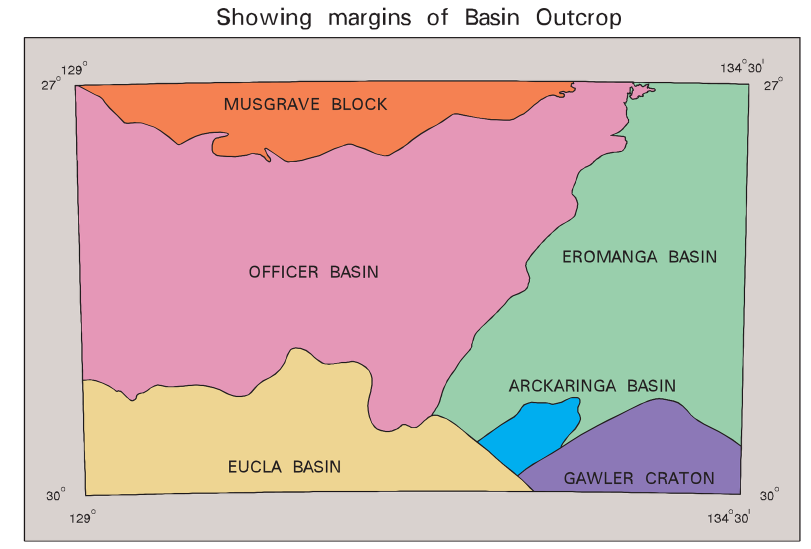
INDEX TO 1:250 000 MAPS



Computer generated from MESA GIS database

GEOLOGICAL PROVINCES

Showing margins of Basin Outcrop



Cartography by the Mapping Section, Drafting Services Branch, Department of Mines and Energy, 191 Greenhill Road, Parkside 5063, South Australia.

Map generated from digital data using Arc/Info software.

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GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 4

Geological Map

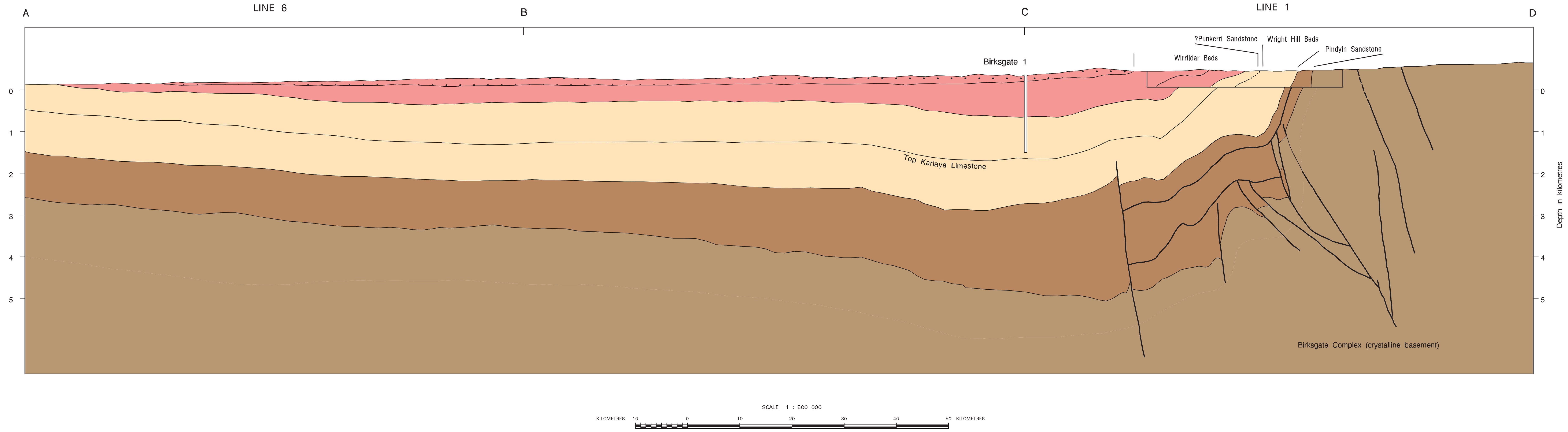
1995

OFFICER BASIN
SOUTH AUSTRALIA
Geological Cross-section

by G.W.Krieg

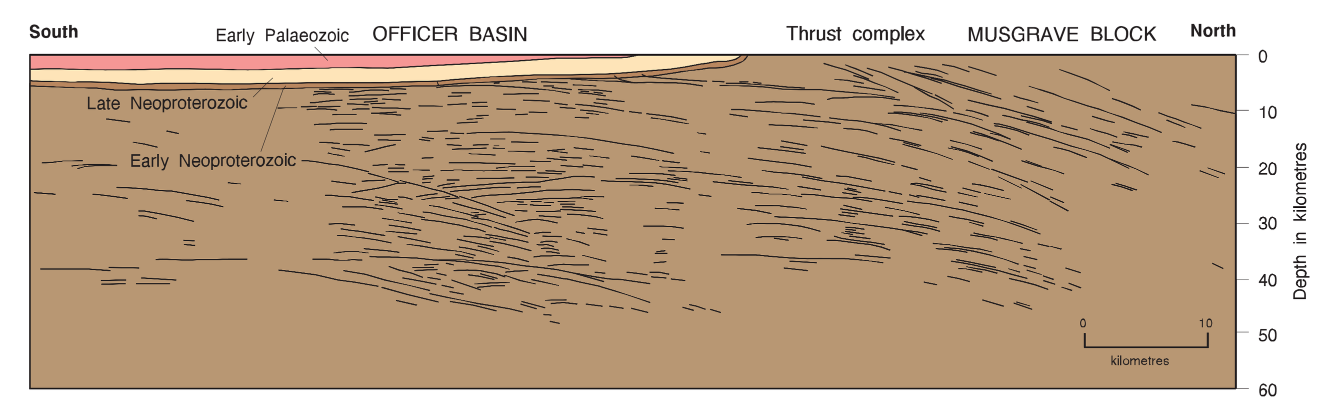
SECTION A-B-C-D

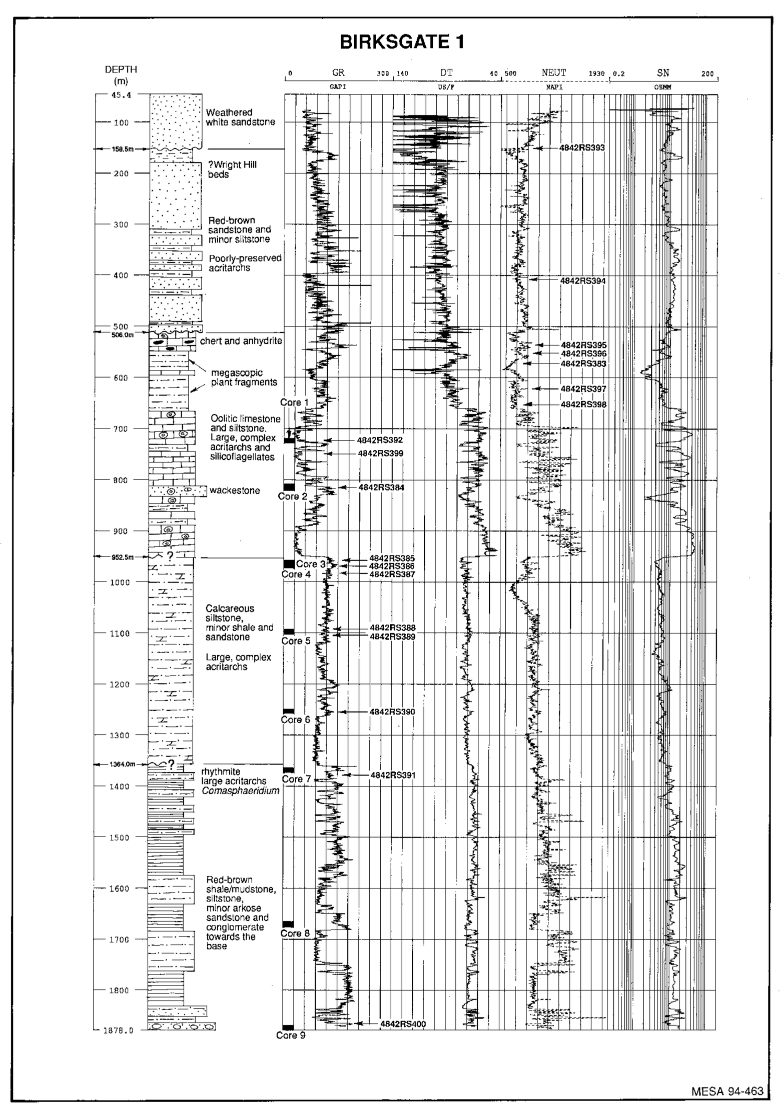
V:H = 8:1



LINE 6
DEEP SEISMIC REFLECTION PROFILE SHOWING MID-CRUSTAL THRUSTS

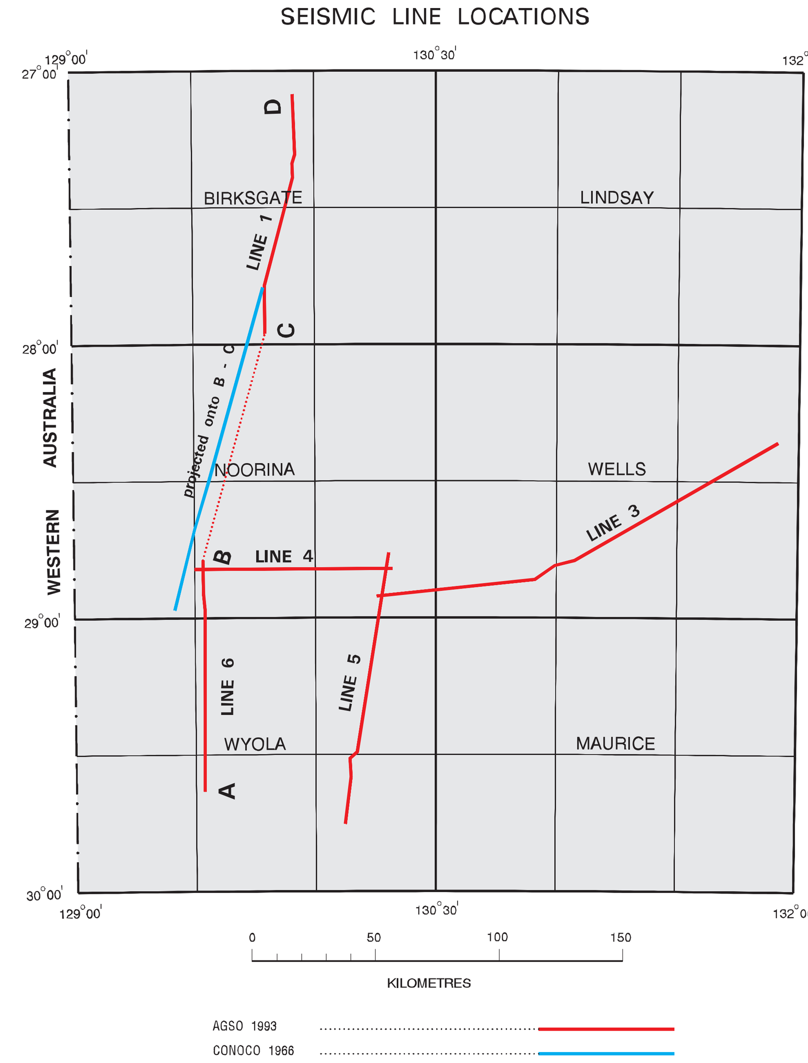
LINE 1
DEEP SEISMIC REFLECTION PROFILE SHOWING MID-CRUSTAL THRUSTS



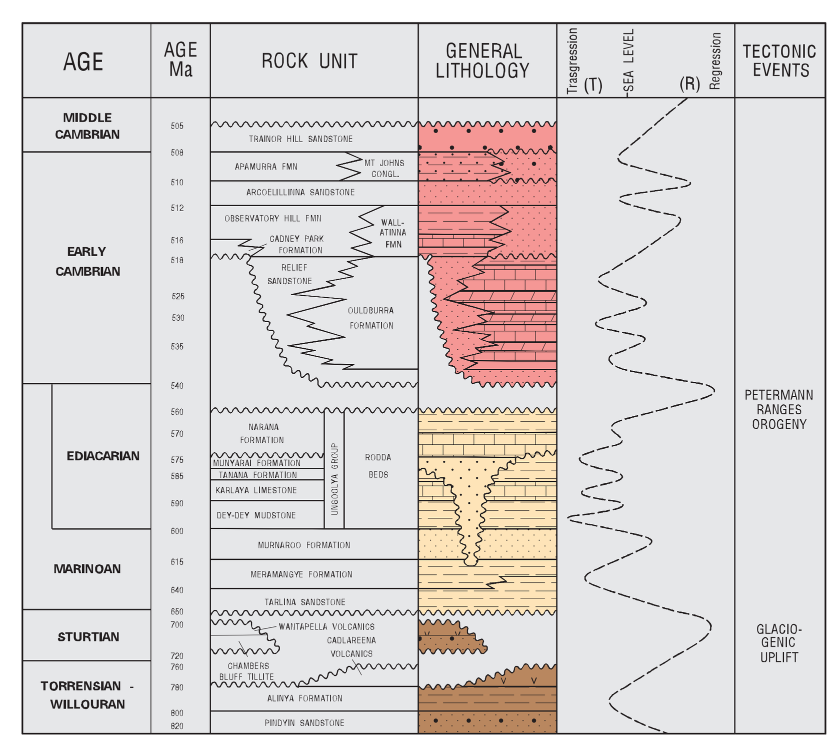


Text-figure 5 Lithological log of Birksgate 1

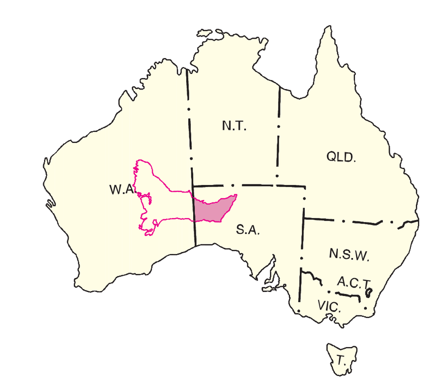
SEISMIC LINE LOCATIONS



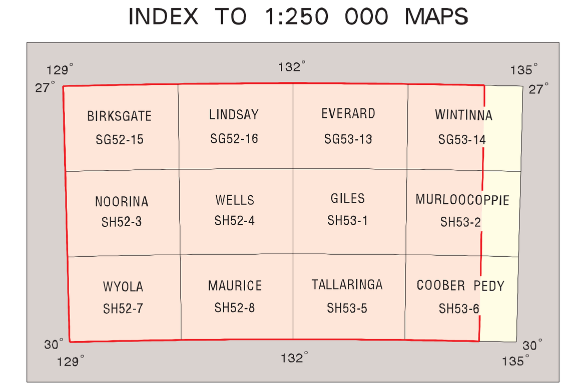
GEOLOGICAL SUMMARY



STUDY AREA



INDEX TO 1:250 000 MAPS



CROSS SECTION

The geological cross-section, located west of the Narrai Ridge, transects the Birksgate sub-basin approximately normal to basin trend. It combines the AGSO 1993 and the CONOCO 1966 seismic data, the main reflectors having been tied to data further east where drillhole and seismic control has enabled a coherent regional subsurface stratigraphy to be established.

The uppermost reflector, believed to be the Cambrian-Precambrian boundary, is tied to a prominent wireline log discontinuity in Birksgate-1 drillhole on the section line (LINE 1). This feature marks the top of a dense calcareous siltstone that forms part of the Ungoolya Group. The next lower reflector, which occurs below Birksgate-1 TD, represents Karlaya Limestone. The remaining two reflectors are, respectively, Alinya Formation (containing evaporites) and Birksgate Complex (crystalline basement). At the north end of the line the near-surface seismic data is thought to be unreliable for identifying geological boundaries because of weathering/velocity unknowns. Instead, the geology has been complied from detailed examination of shothole cuttings, rare small outcrop patches, and "broad brush" projection of a poorly outcropping Wirrildar Beds succession from 30km to the west. Local stratigraphic names for Line 1 (Major & Teluk, 1973) are shown on the cross section tentatively correlated with the general basin stratigraphy. From the youngest these units are Wirrildar Beds, Punkerri Sandstone, Wright Hill Beds and Pindyin Sandstone, the latter unit incorporating the Alinya Formation interval in its original definition.

DEEP SEISMIC SECTIONS (J.F. Lindsay)

Results from the AGSO 1993 deep-seismic survey show that the crust beneath the region is approximately 42 km thick and is pervaded by a complex of northward-dipping lineaments most of which terminate erosionally against the sediments of the Officer Basin and are interpreted as a pre-basin fault complex. In some areas these faults were reactivated and played a major role in basin evolution.

Seismic line 93AGSO.L1 (see also Plate 12) provides a clear image of the reactivated thrust complex that controlled the structure of the basin's northern margin. The sedimentary rocks at the basin margin form a steeply dipping monoclinal upturn. Within the Musgrave Block a series of shallow north-dipping thrust faults appears at depths of 30 km extending for more than 40 km towards the surface. At approximately 17 km from the erosional margin of the basin, the faults bifurcate and at depths less than 9 km steepen slightly and are directed towards the surface to the north of the basin margin. The dip of the deeper faults shallows and is directed towards the base of the sedimentary fill of the basin. One major thrust fault complex can be seen to disrupt the basal layers of the succession slightly before paralleling the strata. The lower most units of the basin, especially the Alinya Formation, contain evaporites which accommodated at least some of the strain.

The steep northern margin of the basin is thus a monoclinal upturn or roll back resulting from deformation during the Late Cambrian Delamerian and Ordovician-Devonian Alice Springs Orogeny on a reactivated complex of north-dipping thrust faults. The margin is therefore erosional and the original northerly extent of the basin unknown. Major structures such as the Ammaroodinna Ridge, along the southern margin of the sub-basins, result from limited localised movement on the deep crustal fault complex during the Petermann Ranges Orogeny. The southern platform (the Murnaroo Platform) is a gentle feature that gradually shallows to the south (slope 0.3 degrees) suggesting that it is the product of broad regional subsidence. The deep seismic data thus provide evidence of thrust faulting in response to compression during the Petermann Ranges, Delamerian and Alice Springs Orogenies. However, in spite of the fact that sequence stacking patterns indicate at least three other phases of subsidence, some perhaps due to thermal decay, there is no clear evidence to link the structure of the underlying crust to these events. Thus a mechanism other than extension mechanical thinning of the crust must be invoked to explain the thermal subsidence stages of basin evolution.

Cartography by the Mapping Section, Drafting Services Branch, Department of Mines and Energy, 191 Greenhill Road, Parkside 5063, South Australia.

Map generated from digital data using Arc/Info software.

It is recommended that this map be referred to as:
Krieg,G.W,, Lindsay,J.F., 1995 -
Geological Cross-section (1:500 000)
In: Lindsay,J.F. (editor), Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy, Adelaide.

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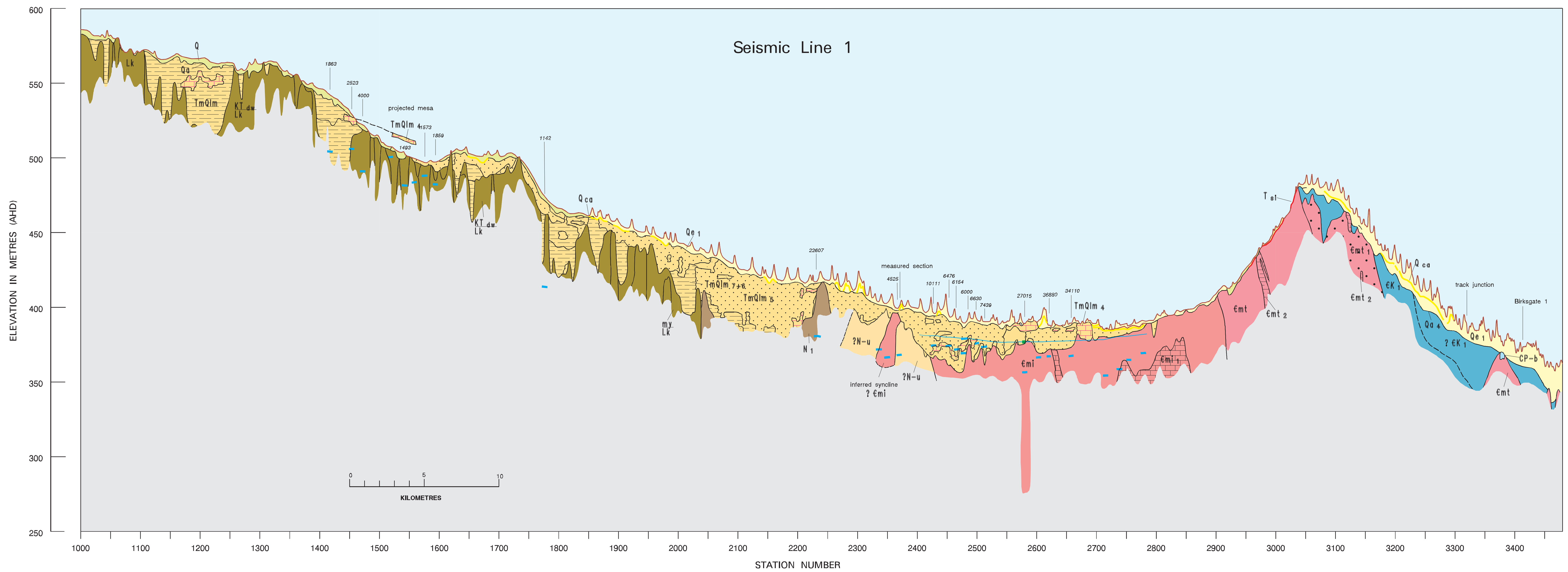
MINES AND ENERGY SOUTH AUSTRALIA

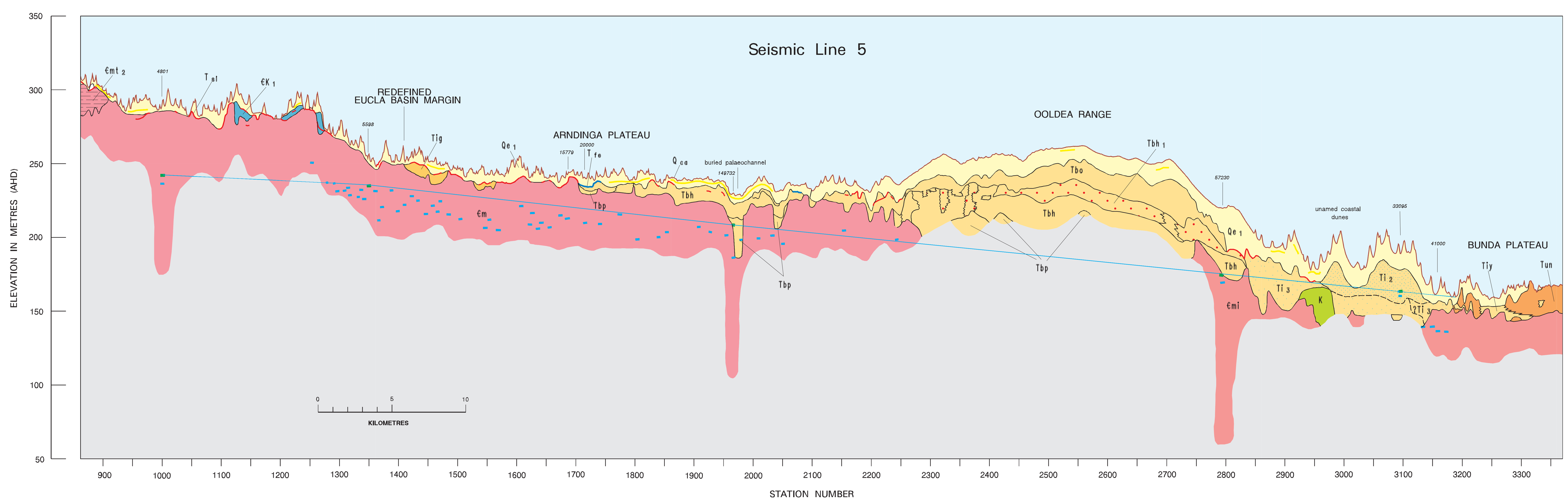
GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

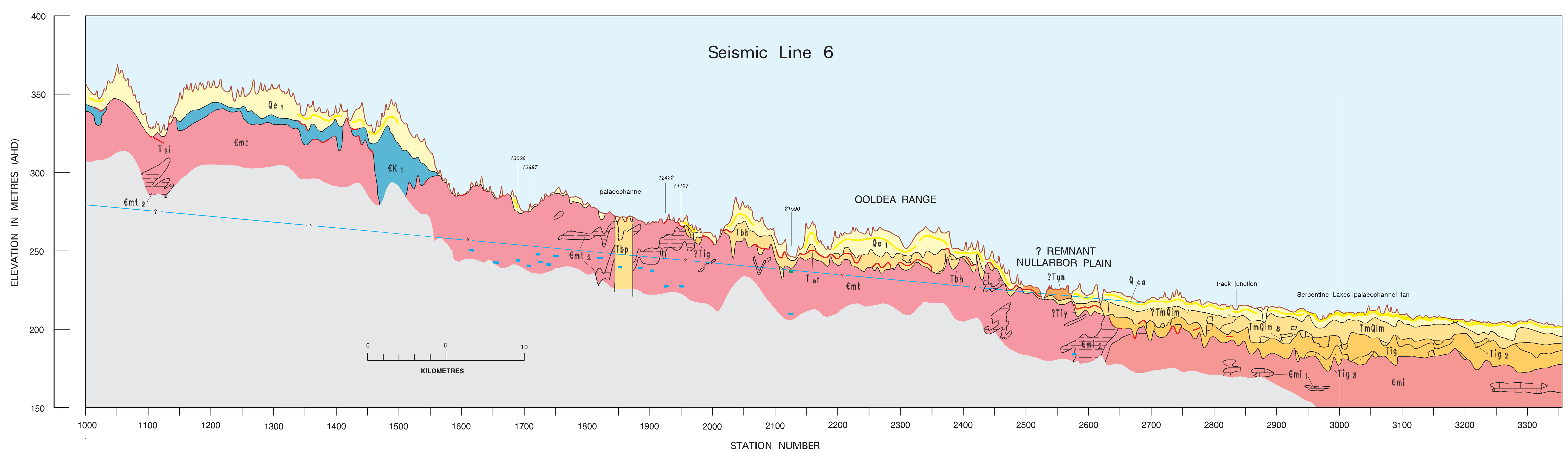
PLATE 5

Geological Cross-section

1995







OFFICER BASIN
SOUTH AUSTRALIA
Near-surface Geological Cross-sections

by M.C.Benbow, G.W.Krieg, J.E.Lau

REFERENCE

Calcrete: Sheet-like or platey masses, concentrically-laminated nodules, palaeosol mottles, and weak, lime-impregnated sand and small, fragile rhizomorphs. .... Q_{ca}

Undifferentiated aeolian and alluvial sediments flanking the Ranges. Includes grits of angular to subangular detritus from the BIRKSGATE COMPLEX. .... Q

GREAT VICTORIA DESERT

Aeolian sand of the dunefield: Indurated red-brown sand passing up to orange-brown calcareous sand and to red-brown sand of dune crests.
Grit lag marks base, or occurs within sequence on southern end of Line 1. .... Qe_1

PALAEOVALLEYS OF THE EUCLA BASIN INCLUDING THE FAN OF THE SERPENTINE LAKES PALAEOVALLEY AND FANS FLANKING MOUNT POONDINNA REGION (North end line 1) AND OF THE EUCLA BASIN

MANGATITJA FORMATION: Alluvial and lacustrine clastics and carbonate. Includes chalcedonic limestone or micrite mudstone ($TmQlm_4$), variably clayey and gritty fluvial sand ($TmQlm_5$) and grit ($TmQlm_8$), flood plain and lacustrine argillaceous, partly sandy mud ($TmQlm_7$ - red-brown upper part, and $TmQlm_6$ - green, blue grey and grey lower part). The unit forms upper part of the fan of the Serpentine Lakes Palaeochannel. Lower part may equate with Tig. .... TmQlm, $TmQlm_4$, $TmQlm_5$, $TmQlm_8$, $TmQlm_7$, $TmQlm_6$

GARFORD FORMATION: Lacustrine and floodplain green, blue-grey and grey mud including calcareous mudstone. Includes limestone and dolomite (Tig_2) and local fluvial basal sands (Tig_3). Unit may be mottled or reddened, and basal sands may be silicified. This unit forms lower part of the fan of the Serpentine Lakes Palaeochannel. .... Tig_2, Tig, Tig_3

NULLARBOR LIMESTONE: Marine platform deposit of bioclastic skeletal limestone with packstone and minor porous grainstone. Indurated and crystallised.
YARLE SANDSONE: Very fine to fine, well sorted sand, clayey sand and stiff clay-sand with scattered medium to very coarse grains. .... Tun, Tiy

Yellow, yellow-brown weathering and rhizomorph formation. Rhizomorphs may be silicified or lime cemented. Developed primarily in $ꞒK_1$ and Tbo. .... TQ_{we1}

Ferricrete: Various forms including some with an associated underlying mottled profile. May have associated polycyclic lags of buckshot gravel. .... T_{fe}

Silcrete: Pedogenic forms characterised by floating fabrics, columnar habit and helmut cap structures; groundwater forms characterised by glassy aspect and framework-supported fabrics. .... T_{sl}

Deep weathering: White to off-white, chemical alteration products (mainly clay). Saprolite and clay-quartz rock extensively formed in BIRKSGATE COMPLEX (weathering front indicated). May be capped by ferricrete and silcrete in compound (polycyclic) profiles. .... KT_{dw}

Unnamed sediments: Terriginous quartz-rich partly carbonaceous sand and mud, minor grits and rarely shelly (Ti_3). Medium-grained, well-sorted quartz sand of coastal dune cores (Ti_2). .... Ti_2, Ti_3

Aeolian quartz sand, in part spicule-bearing, of the Ooldea Range. .... Tbo
HAMPTON SANDSTONE: Marine and esturine sand and grit. In part siliceous sponge spicule-bearing. Prominent beach or near shore grit marker of Line 5 (Tbh_2). Local pebbly basal grits of Line 6 mark marine flooding surface. .... Tbh, Tbh_2
PIDINGA FORMATION: Partly carbonaceous and wood-bearing quartz sand and grit of buried palaeovalleys. Muddy, very fine sand to sandy mud at base of, and interbedded in Hampton Sandstone deposited in estuaries and interdistributary bays. May contain spicules. .... Tbp

Undifferentiated deposits of BIGHT BASIN. Includes partly carbonaceous mud and sand intersected on southern end of Line .... K

?BOORTHANNA FORMATION EQUIVALENT: Conglomeratic, poorly sorted sand with very small rounded pebbles of diverse lithologies. .... ?CP-b

Unamed sand: Sand, gritty sand (bimodal) and partly pebbly local basal grit. Unit is clean, white to grey at depth and weathered (TQ_{we1}) at top. Locally a marked hiatus with underlying Officer Basin sediments. .... $ꞒK_1$

OFFICER BASIN

MARLA GROUP .... Ꞓm

TRAINOR HILL SANDSTONE: Very fine to fine grained well sorted kaolinitic sandstone. In upper part may be medium to coarse grained with some rounded, very coarse to granule sized grains ($Ꞓmt_1$). Interbeds of micro-micaceous mudstone including a dark grey organic mud marker on Line 6 ($Ꞓmt_2$). .... Ꞓmt

WIRRILDAR BEDS: Brown, maroon, purple, variably micaceous mudstone and very fine sandstone. Calcareous mudstone and carbonate including ooid-bearing micrite ($Ꞓmi_1$). .... Ꞓmi

PUNKERRI SANDSTONE: Very fine to medium grained white clayey and siliceous sandstone and purple, hard, well-sorted ferruginous sandstone. .... N-u

Undifferentiated WRIGHT HILL BEDS, ALINYA FORMATION and PINDYIN SANDSTONE. Sandstone, microcrystalline carbonate and varicoloured claystone. .... N_1

MUSGRAVE COMPLEX

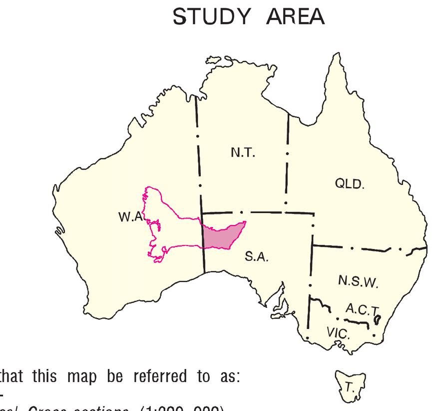
BIRKSGATE COMPLEX: Granitic gneiss and foliated medium to coarse grained PERMANO ADAMELLITE, which is biotite and hornblende-bearing in part, and porphyritic (Lk).
Mylonite (my) near southern end of line. .... Lk, my

Ground surface (A.H.D.) ....
Salinity (mg/L) 4332
Standing water level ....
Water cut ....
Potentiometric surface, tentative ....

The cross sections of near-surface geology were derived from the logging of some 2500 shotholes drilled for the 1993 AGSO/MESA seismic survey. Holes were nominally 40 metres deep and cuttings were collected every half-rod length, i.e. approximately each 2.25 metres. Lithologs were compiled onto accurate topographic profiles (horizontal scale approximately 1:45000; V/H = 40) prepared from seismic line levelling data, and then integrated into a regional lithostratigraphic interpretation. The interpretation was then generalised and simplified to produce the geological cross-sections on Plates 6 and 7.

Shotholes intersected Musgrave Block (line 1), Officer Basin, Eucla Basin (lines 5 and 6), Bight Basin (line 5) and Cainozoic dunefield and palaeovalley deposits. Many holes also intersected groundwater (see plates 9 and 10). Selected water cuts, with salinities, and a tentative piezometric surface have been added to the cross-sections.

STUDY AREA



It is recommended that this map be referred to as:
Benbow,M.C., 1995 -
Near-surface Geological Cross-sections (1:200 000)
In: Lindsay,J.F. (editor), Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy, Adelaide.

Published jointly by the Australian Geological Survey Organisation, Canberra and the Department of Mines and Energy, South Australia, as part of the National Geoscience Accord.

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MINES AND ENERGY
SOUTH AUSTRALIA

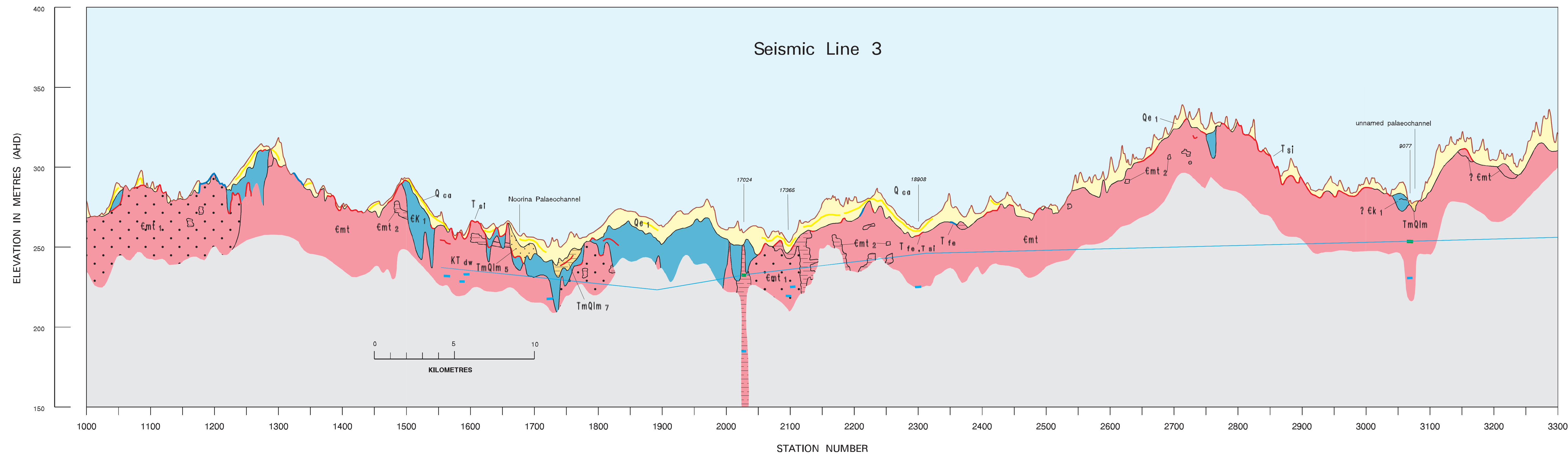
GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA
PLATE 6
Near-surface Geological Cross-sections
1995

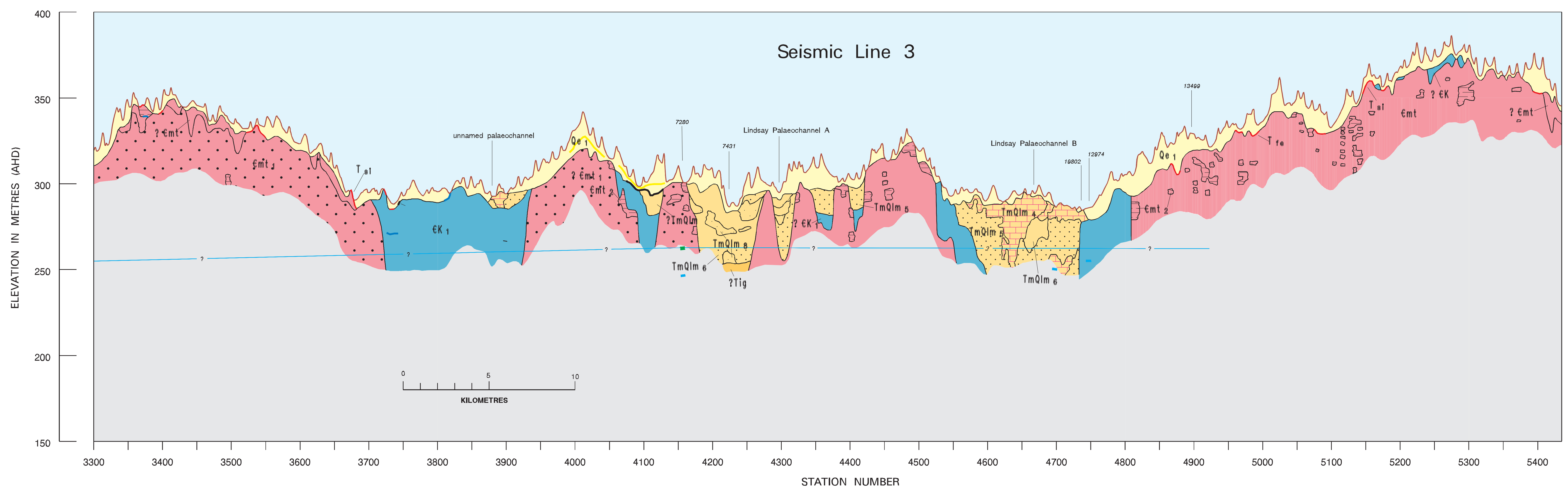
OFFICER BASIN

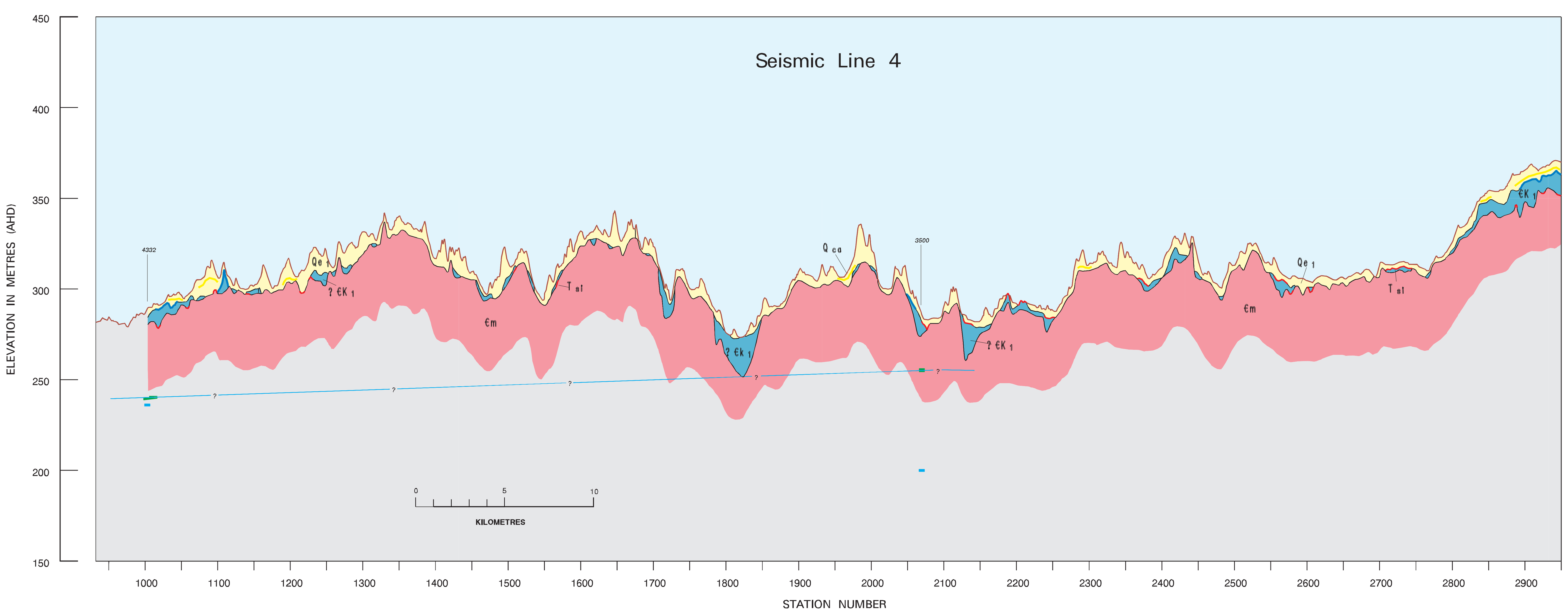
SOUTH AUSTRALIA

Near-surface Geological Cross-sections

by M.C.Benbow, G.W.Krieg, J.E.Lau







R E F E R E N C E

Calcrete: Sheet-like or platey masses, concentrically-laminated nodules, palaeosol mottles, and weak, lime-impregnated sand and small, fragile rhizomorphs.	Q ca
Undifferentiated aeolian and alluvial sediments flanking the Ranges. Includes grits of angular to subangular detritus from the BIRKSGATE COMPLEX.	Q

GREAT VICTORIA DESERT

Aeolian sand of the dunefield: Indurated red-brown sand passing up to orange-brown calcareous sand and to red-brown sand of dune crests. Grit lag marks base, or occurs within sequence on southern end of Line 1.	Qe 1

PALAEOVALLEYS OF THE EUCLA BASIN INCLUDING THE FAN OF THE SERPENTINE LAKES PALAEOVALLEY AND FANS FLANKING MOUNT POONDINNA REGION (North end line 1) AND OF THE EUCLA BASIN

MANGATITJA FORMATION: Alluvial and lacustrine clastics and carbonate. Includes chalcedonic limestone or micrite mudstone ($TmQlm_4$), variably clayey and gritty fluvial sand ($TmQlm_5$) and grit ($TmQlm_8$), flood plain and lacustrine argillaceous, partly sandy mud ($TmQlm_7$ - red-brown upper part, and $TmQlm_6$ - green, blue grey and grey lower part). The unit forms upper part of the fan of the Serpentine Lakes Palaeochannel. Lower part may equate with Tig.	TmQlm, TmQlm 4, TmQlm 5, TmQlm 8, TmQlm 7, TmQlm 6
GARFORD FORMATION: Lacustrine and floodplain green, blue-grey and grey mud including calcareous mudstone. Includes limestone and dolomite (Tig_2) and local fluvial basal sands (Tig_3). Unit may be mottled or reddened, and basal sands may be silicified. This unit forms lower part of the fan of the Serpentine Lakes Palaeochannel.	Tig 2, Tig, Tig 3
NULLARBOR LIMESTONE: Marine platform deposit of bioclastic skeletal limestone with packstone and minor porous grainstone. Indurated and crystallised.	Tun
YARLE SANDSONE: Very fine to fine, well sorted sand, clayey sand and stiff clay-sand with scattered medium to very coarse grains.	Tiy
Yellow, yellow-brown weathering and rhizomorph formation. Rhizomorphs may be silicified or lime cemented. Developed primarily in $€K_1$ and Tbo.	TQ we1
Ferricrete: Various forms including some with an associated underlying mottled profile. May have associated polycyclic lags of buckshot gravel.	T fe
Silcrete: Pedogenic forms characterised by floating fabrics, columnar habit and helmut cap structures; groundwater forms characterised by glassy aspect and framework-supported fabrics.	T si
Deep weathering: White to off-white, chemical alteration products (mainly clay). Saprolite and clay-quartz rock extensively formed in BIRKSGATE COMPLEX (weathering front indicated). May be capped by ferricrete and silcrete in compound (polycyclic) profiles.	KT dw
Unnamed sediments: Terriginous quartz-rich partly carbonaceous sand and mud, minor grits and rarely shelly (Ti_3). Medium-grained, well-sorted quartz sand of coastal dune cores (Ti_2).	Ti 2, Ti 3
Aeolian quartz sand, in part spicule-bearing, of the Ooldea Range.	Tbo
HAMPTON SANDSTONE: Marine and esturine sand and grit. In part silceous sponge spicule-bearing. Prominent beach or near shore grit marker of Line 5 (Tbh_2). Local pebbly basal grits of Line 6 mark marine flooding surface.	Tbh, Tbh 2
PIDINGA FORMATION: Partly carbonaceous and wood-bearing quartz sand and grit of buried palaeovalleys. Muddy, very fine sand to sandy mud at base of, and interbedded in Hampton Sandstone deposited in estuaries and interdistributary bays. May contain spicules.	Tbp
Undifferentiated deposits of BIGHT BASIN. Includes partly carbonaceous mud and sand intersected on southern end of Line	K
?BOORTHANNA FORMATION EQUIVALENT: Conglomeratic, poorly sorted sand with very small rounded pebbles of diverse lithologies.	?CP-b
Unamed sand: Sand, gritty sand (bimodal) and partly pebbly local basal grit. Unit is clean, white to grey at depth and weathered (TQ_{we1}) at top. Locally a marked hiatus with underlying Officer Basin sediments.	€K 1

OFFICER BASIN

MARLA GROUP	€m
TRAINOR HILL SANDSTONE: Very fine to fine grained well sorted kaolinitic sandstone. In upper part may be medium to coarse grained with some rounded, very coarse to granule sized grains ($€mt_1$). Interbeds of micro-micaceous mudstone including a dark grey organic mud marker on Line 6 ($€mt_2$).	€mt
WIRRILDAR BEDS: Brown, maroon, purple, variably micaceous mudstone and very fine sandstone. Calcareous mudstone and carbonate including ooid-bearing micrite ($€mi_1$).	€mi
PUNKERRI SANDSTONE: Very fine to medium grained white clayey and siliceous sandstone and purple, hard, well-sorted ferruginous sandstone.	N-u
Undifferentiated WRIGHT HILL BEDS, ALINYA FORMATION and PINDYIN SANDSTONE. Sandstone, microcrystalline carbonate and varicoloured claystone.	N 1

MUSGRAVE COMPLEX

BIRKSGATE COMPLEX: Granitic gneiss and foliated medium to coarse grained PERMANO ADAMELLITE, which is biotite and hornblende-bearing in part, and porphyritic (Lk). Mylonite (my) near southern end of line.	Lk, my

Ground surface (A.H.D.)	(red line)
Salinity (mg/L)	4332
Standing water level	(green bar)
Water cut	(blue bar)
Potentiometric surface, tentative	— ? —

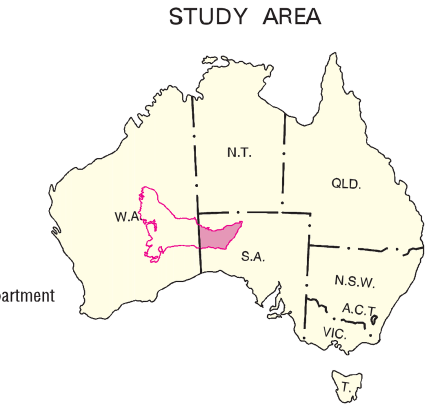
The cross sections of near-surface geology were derived from the logging of some 2500 shotholes drilled for the 1993 AGSO/MESA seismic survey. Holes were nominally 40 metres deep and cuttings were collected every half-rod length, i.e. approximately each 2.25 metres. Lithologs were compiled onto accurate topographic profiles (horizontal scale approximately 1:45000; V/H = 40) prepared from seismic line levelling data, and then integrated into a regional lithostratigraphic interpretation. The interpretation was then generalised and simplified to produce the geological cross-sections on Plates 6 and 7.

Shotholes intersected Musgrave Block (line 1), Officer Basin, Eucla Basin (lines 5 and 6), Bight Basin (line 5) and Cainozoic dunefield and palaeovalley deposits. Many holes also intersected groundwater (see plates 9 and 10). Selected water cuts, with salinities, and a tentative piezometric surface have been added to the cross-sections.

Cartography by the Mapping Section, Drafting Services Branch, Department of Mines and Energy, 191 Greenhill Road, Parkside 5063, South Australia.

Map generated from digital data using Arc/Info software.

STUDY AREA



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GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 7

Near-surface Geological Cross-sections

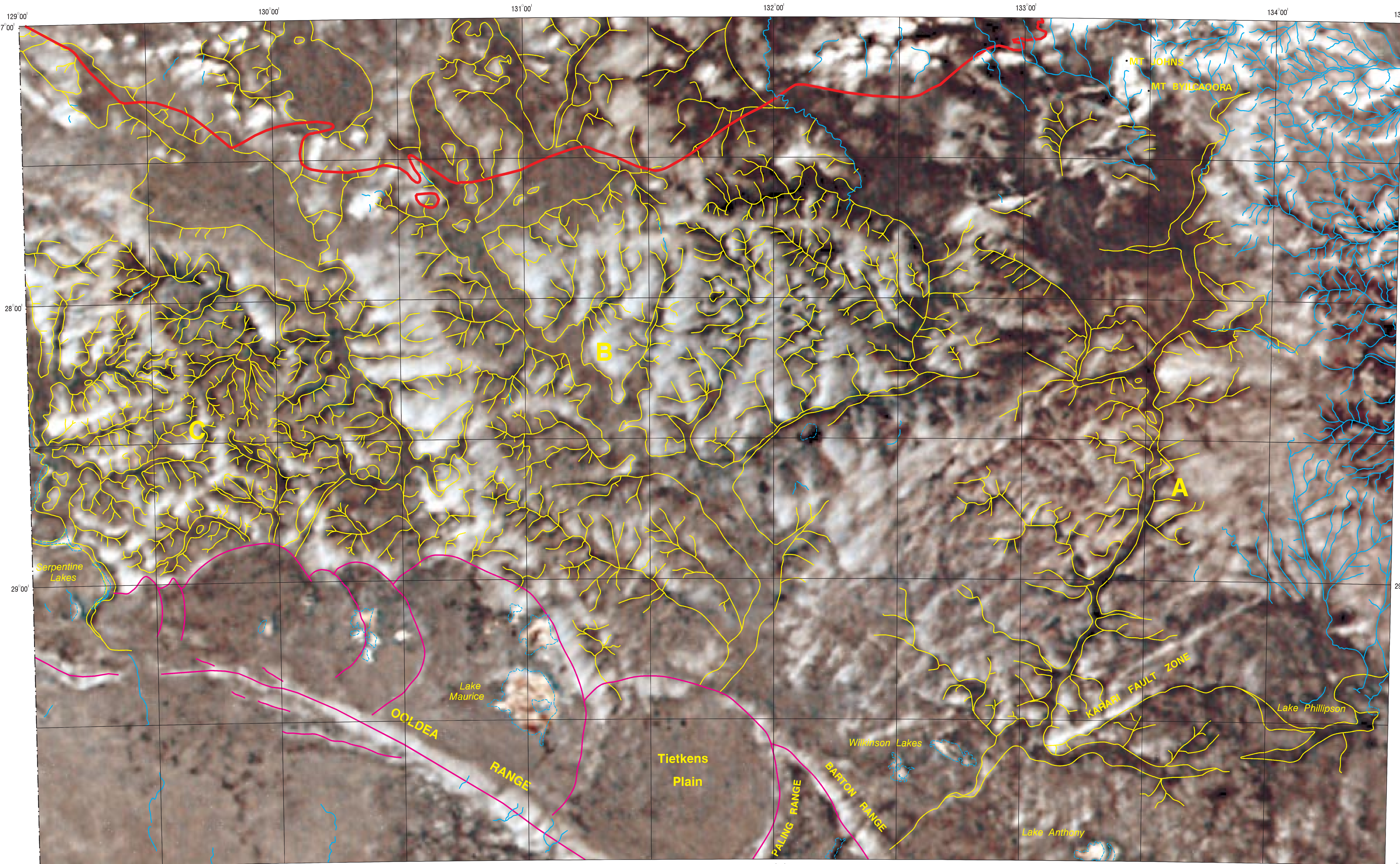
1995

OFFICER BASIN

SOUTH AUSTRALIA

Palaeodrainage

By L. Statham-Lee



SCALE 1 : 1 000 000

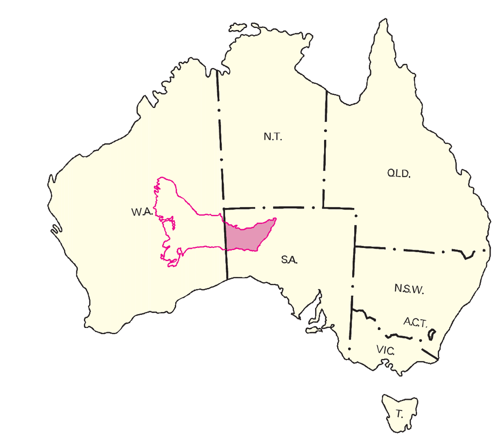
KILOMETRES 20 0 20 40 60 80 100 KILOMETRES

Lambert Conformal Conic Projection

Standard Parallels 27°15'S 30°15'S.

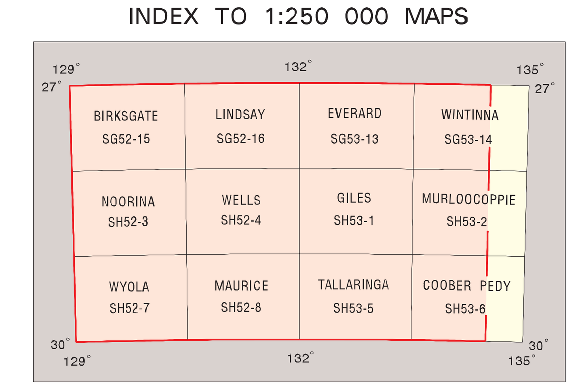
Central Meridian 132°E.

STUDY AREA



LOCALITY PLAN

INDEX TO 1:250 000 MAPS



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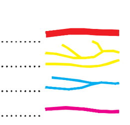

NOAA-AVHRR SATELLITE

NOAA-AVHRR (National Oceanic and Atmospheric Administration - Advanced Very High Resolution Radiometer) is a sun-synchronous near-polar orbiting satellite. An orbital period of 102 minutes by the two active satellites means complete coverage can be obtained within a 12 hour period resulting in multitemporal (same day, different time) and multidate (same time, different day) images.

The satellite measures various wavelengths of emitted and reflected radiation from the earth's surface in five spectral intervals. These correspond to; channel 1, 0.55-0.9 micrometres (visible red); channel 2, 0.725-1.1 micrometres (near IR window); channel 3, 3.55-3.93 micrometres (thermal IR window); channel 4, 10.5-11.5 micrometres (thermal IR window); and channel 5, 11.5-12.5 micrometres (thermal IR window) (Dubach and Ng, 1988). The channels have a spatial resolution of 1.1 km at nadir and gross distortions which occur along the swath edge are corrected using geometric rectification by the data supplier.

The radiant temperature recorded by NOAA-AVHRR is a product of a material's kinetic temperature and its emissivity. Emissivity is the measure of a material's ability to absorb and reradiate thermal energy (Kahle, 1980). This varies greatly depending on moisture content, mineral composition and texture of the landsurface. The amount of surface radiant temperature detected is related to night time cooling mechanisms, amount of insolation and the thermal properties of the material (Short and Stuart, 1982).
A pre-dawn image, pass time of 0400 hrs EST, was obtained from the NOAA-AVHRR 11 satellite coinciding with the cross over in the diurnal heating and cooling cycle, which corresponds to the maximum thermal contrast between surface sediments and underlying material (Drury, 1988). As a result thermal features in the underlying material are revealed, instead of being masked by the overlying sands and soils (as they are during the day). For the same reason, the pre-dawn image also provides maximum contrast between different thermal inertias within the underlying materials (Tapley, 1988).

IMAGE PROCESSING

A pre-dawn NOAA-AVHRR satellite image of the 21st August 1993 was obtained from CSIRO, Division of Oceanography, Tasmania, temperature calibrated (increases .1°C for every increment increase in brightness value). Once a temperature calibration has been applied to the data, dark tones in the image represent cool areas and brighter tones indicate warmer regions.

The palaeodrainage of the Officer Basin is clearly identifiable with very little processing. However processing is required to enhance the detail of the satellite image. The three thermal channels 3, 4 and 5 were displayed as a three band colour composite on red, green and blue colour guns respectively. An 11 x 11 matrix high pass filter was applied to each band to enhance the course of the palaeodrainage.

INTERPRETATION

The palaeodrainage appears dark in the NOAA-AVHRR satellite pre-dawn image because the channel fill sediments have a lower thermal inertia and are cooler than the surrounding basin sediments.

The 1.1 km resolution of the NOAA-AVHRR satellite means only trunk valleys and major tributaries are visible within the image. However it is still possible to map the palaeodrainage in the Officer Basin in considerable detail (Statham-Lee 1994).

Palaeodrainage seen in the image represents all of the drainage active at some stage during the Tertiary and probably the Pleistocene.

A - TALLARINGA PALAEODRAINAGE SYSTEM

The upper reaches of the Tallaringa Palaeodrainage system are not well defined in the NOAA-AVHRR image. The cool areas surrounding the ranges of Mt Johns and Mt Byilcaoora still support modern drainage. Fluvial sediments are probably providing the cooler response compared with the warmer, denser ranges. The entire area may once have been the catchment for the Tallaringa Palaeodrainage System. Now only segmented, intermittently flowing drainage exists. To the east the upper reaches of the Tallaringa Palaeodrainage System appear offset as it crosses a NW-SE trending lineament and then continues southwards. The Tallaringa Palaeodrainage System is Eocene to Pleistocene in age (Barnes and Pitt, 1976).

The Tallaringa Palaeodrainage System flows south until it is met by the Garford Palaeochannel from from the east. In the satellite image the Garford Palaeochannel is visibly disjointed. It appears the Garford Palaeochannel flowed to the west but evidence found in the Lake Phillipson depression suggests flow was actually to the east. Consequently the Garford Palaeochannel may have undergone a reversal in flow, possibly due to activation of the Karari Fault Zone (Barnes and Pitt, 1976) or it could represent an overflow channel for the Lake Phillipson depression (Benbow and Pitt, 1978).

B - UNNAMED

To the west of the Tallaringa Palaeodrainage System a large roughly semicircular drainage pattern is evident draining from a domal feature. The northern margin of the dome coincides with the contact between the Musgrave Block and Officer Basin. Palaeodrainage on the eastern side of the dome flows into a SW trending palaeochannel and on the west into a major trunk valley flowing SE. These two converge and continue in a southerly direction. Before reaching Tietkens Plain two parallel NW-SE trending tributaries enter the palaeochannel from the west.

C - SERPENTINE LAKES

The Serpentine Lakes, suggested by Krieg (1971) to be a Pleistocene meandering river system is likely, also, to have begun in the Tertiary. The lakes' elongate shape and arrangement suggest they are the remaining fragments of a major trunk valley heading southwards with extensive tributaries entering from the east. Topographic depressions mapped by Krieg (1971) in the Serpentine Lakes area correspond to drainage in the image. From the satellite image the palaeochannel can be interpreted to continue through the Ooldea Range, being responsible for the present break in the range, before emptying into the Tertiary sea.

Adjacent to the Serpentine Lakes in the east is a series of NW-SE trending ridges separated by parallel corridors of SE draining palaeosystems. In one instance central within this region, drainage is endoreic. The palaeosystems finally empty in the circular features behind the Ooldea Range, which are suggested to be Tertiary to Pleistocene back water lagoons.

The bright areas within the satellite image represent more dense, warmer rocks beneath the Great Victoria Desert. These areas can be interpreted as topographic highs from which extensive drainage once shed.

Various other features beside the palaeodrainage are also prominent on the image. The Ooldea, Paling and Barton ranges are visible because they consist of denser rock than the surrounding dune sands and therefore have a higher thermal inertia (Tapley, 1988). The ranges are known to be Tertiary coastal dunes (Benbow, 1988) representing Tertiary shorelines.

Tietkens Plain (Benbow, 1988) is an easily discernible, dark (cool) circular depression, bounded to the east by the Paling Range with a further two circular features occurring to the west. A phenomenon known as cold air ponding (Tapley, 1988) may result in these features being so prominent. Cool air is trapped in the circular depressions and is recorded by the satellite resulting in the features seen in the image. The most western feature is surrounded by a series of curvilinear parallel lines which have been interpreted as beach ridges (Benbow, 1988).

The contact between the Musgrave Block and Officer Basin, and the deformed basin sediments adjacent to the south are represented by a dark curved linear zone within the image. Water seepage along its length is probably highlighting this zone. It could also be influenced by the difference in average density of fractured rocks within this zone compared to the sediments and rocks of the Officer Basin and Musgrave Block. The change in density and/or water seepage have contributed to a lower thermal inertia measured within this zone making it appear as a dark feature. Smaller tributaries can be observed draining northwards into the contact zone. Activity along the contact zone may have influenced the palaeodrainage across this region by constricting flows until substantial water collected to continue flowing southwards.

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NOAA-AVHRR satelite image for 21st August 1993 supplied by CSIRO, Division of Oceanography, Tasmania.

It is recommended that this map be referred to as:
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GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 8

Palaeodrainage

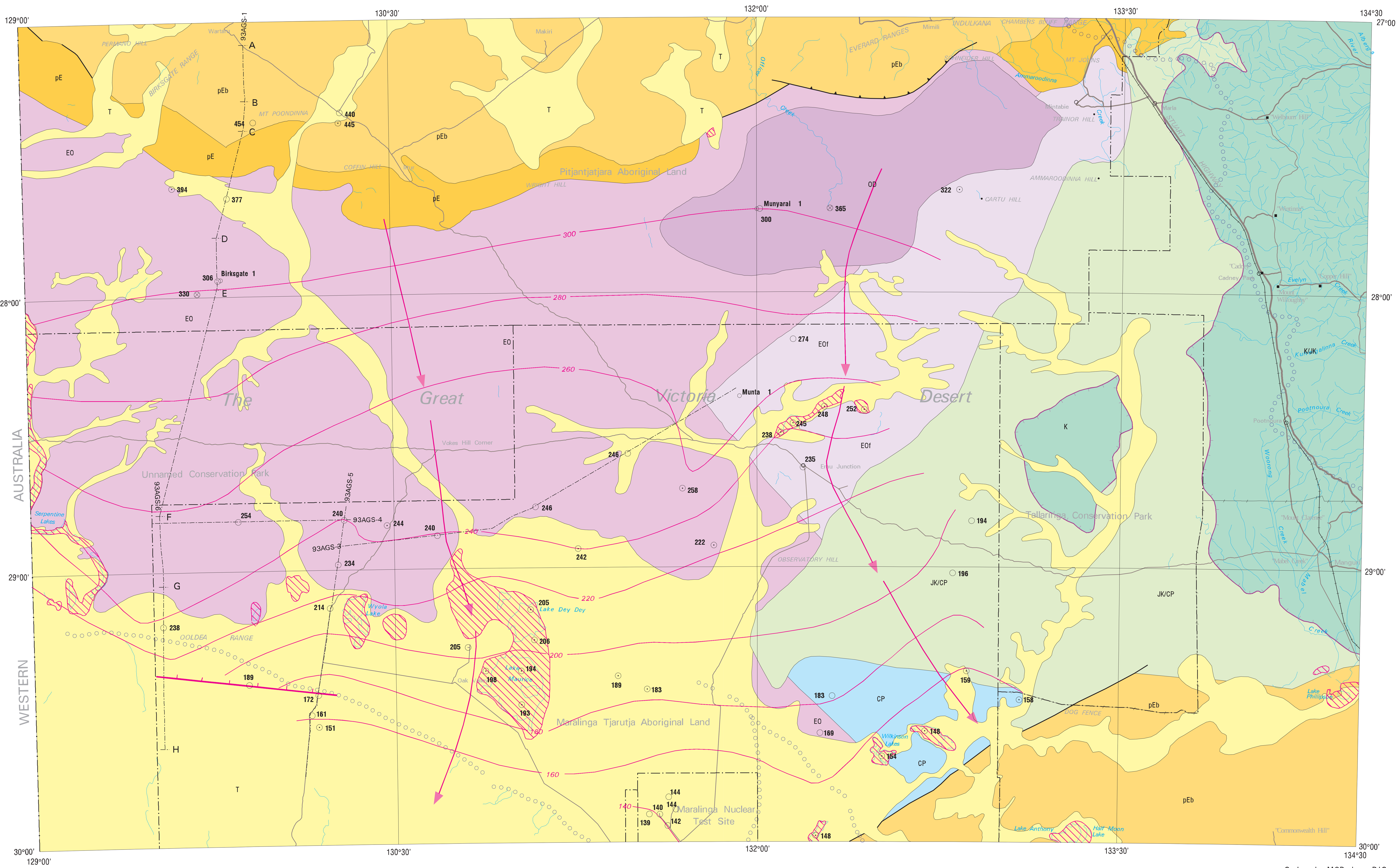
1995

OFFICER BASIN

SOUTH AUSTRALIA

Groundwater Systems

by J.E.Lau, A.R.Dodds, P.Tewkesbury and G.Jacobson



Scale 1:1 000 000

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E

Eucla Basin and palaeo drainages	T	Sand, clay, dolomite (including Garford Formation and Mangatitja Formation) of palaeodrainages. Sand (Ooldea Sand, Hampton Sandstone Pidinga Formation) and limestone (Nullarbor Limestone) of basin. Moderate-very high salinity groundwater
Eromanga Basin	K	Mudstone (Bulldog Shale). Main confining bed of Great Artesian Basin
	JK	Sandstone (Cadna-Owie Formation, Algebuckina Sandstone). Basal or 'J' aquifer of Great Artesian Basin beneath Bulldog Shale. Low-moderate salinity groundwater
Arckaringa Basin	CP	Mudstone (Stuart Range Formation) above sandstone and sandy claystone (Boorthanna Formation).
Officer Basin	OD	Sandstone and siltstone (Mintabie Beds, Blue Hills Sandstone) Triple aquifer system in Munyarai 1. Low salinity groundwater on northern margin. Moderate salinity elsewhere.
	EO	Sandstone, shale and carbonate (including Trainor Hill Sandstone) Moderate - high salinity groundwater. Low salinity in Birksgate 1 and rare thin lenses in regional discharge zone.
	EOf	Sandstone , shale and carbonate. Much faulted and overthrust. Low salinity groundwater in northeast, high salinity in southwest
	pE	Mudstone, minor carbonate (Wright Hill Beds). High salinity groundwater
Musgrave Block Gawler Block	pEb	Granite and gneiss some gabbro dykes. Low-moderate salinity groundwater

- Bore, seismic shothole, stratigraphic hole, exploration well
- Direction of groundwater flow
- Barrier to groundwater flow (ticks point to higher permeability)
- Regional groundwater discharge zone
- 280 Contour on potentiometric surface (m AHD)
- Base of confining bed (Great Artesian Basin)
- 158 Groundwater discharge zone (playa) and spot height (m AHD)
- 365 Groundwater recharge zone (floodout, swamp and spot height (m AHD)
- 189 Bore with elevation of standing water level (m AHD)
- Geological boundary
- Fault
- Thrust fault
- Road
- Mintabie Town
- Seismic line
- Surface water divide
- River intermittent
- Lake intermittent

See Plate 10 for explanatory notes

Geology by M.C.Benbow, D.I.Gravestock, G.W.Krieg, MESA and J.F.Lindsay, AGSO
Compiled 1994 by J.E.Lau & G.Jacobson AGSO, A.R.Dodds & P.Tewkesbury MESA
Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
Data processing by K.Reine and E.Bleys, AGSO using Petrosys software
Cartography by V.Ashby, AGSO
Produced by AGSO Cartographic Services Unit using ArcInfo software

Topographic detail based on information supplied by the Department of Environment and Natural Resources, South Australia.

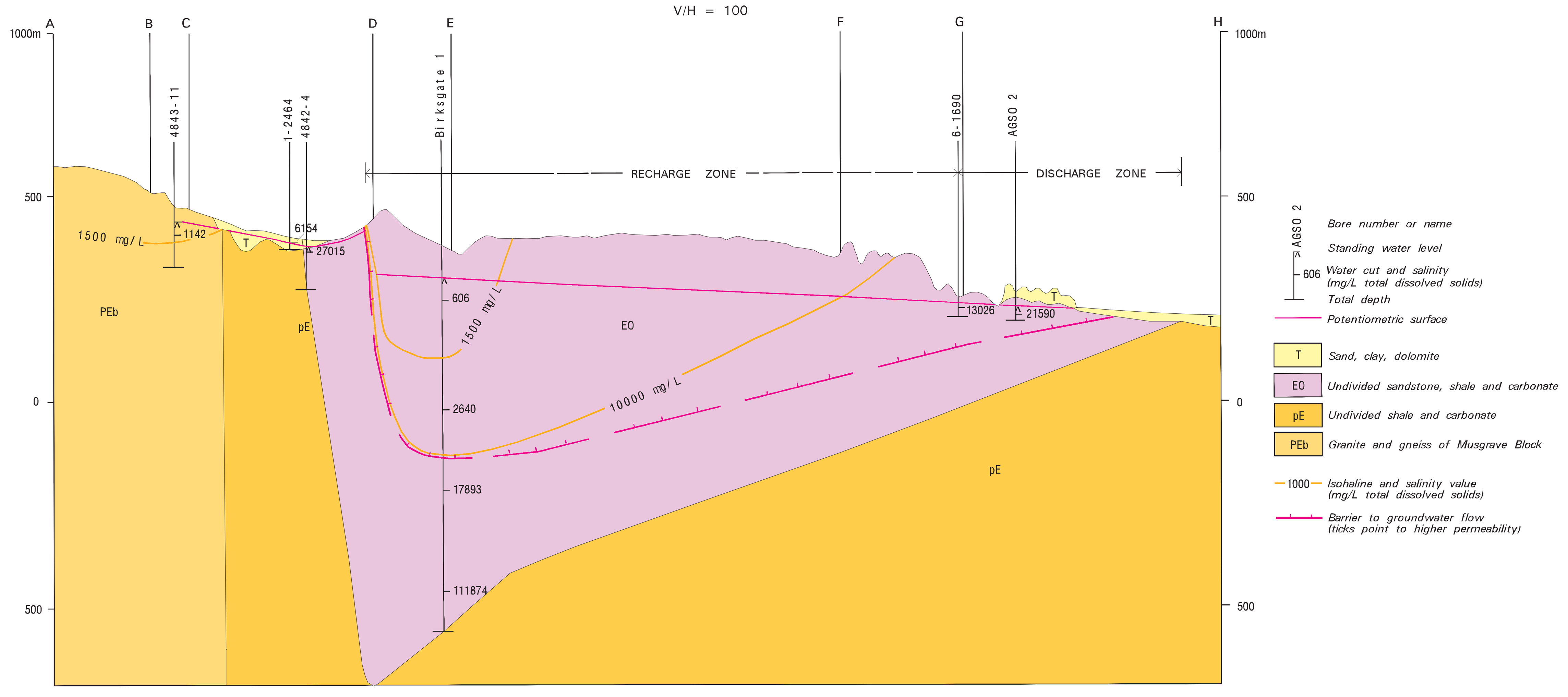
Parks and Reserves supplied by Department of Housing and Urban Development, South Australia.

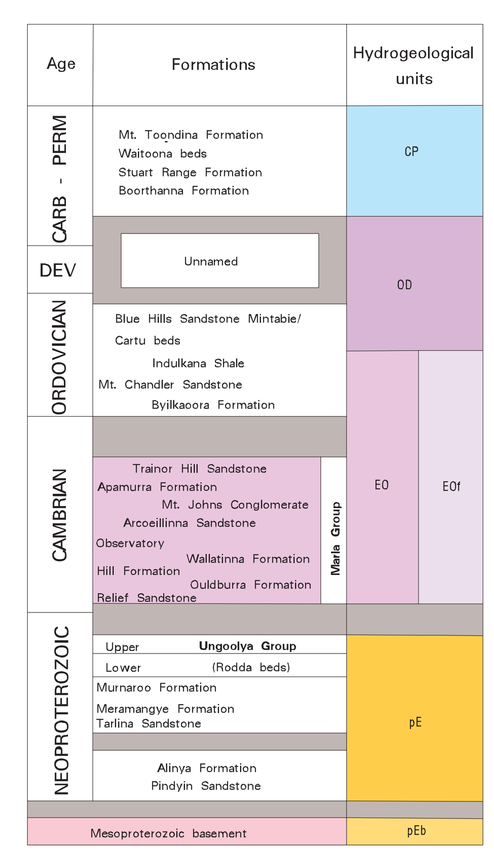
It is recommended that this map be referred to as:
Dodds,A.R., Tewkesbury,P., Jacobson,G., Lau,J.E., 1995 -
Groundwater Systems (1:1 000 000)
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

Published jointly by the Australian Geological Survey Organisation, Canberra, Australia and the Department of Mines and Energy, South Australia, Adelaide, as part of the National Geoscience Mapping Accord

SCHEMATIC CROSS SECTION A-H

V/H = 100





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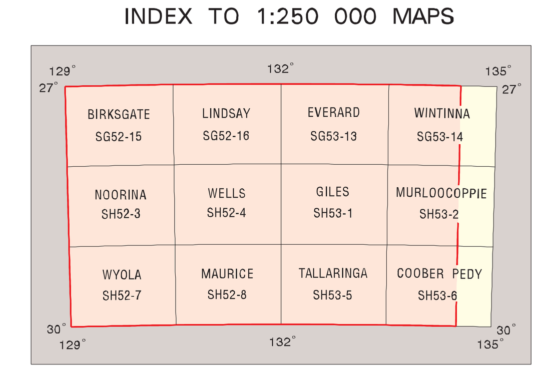
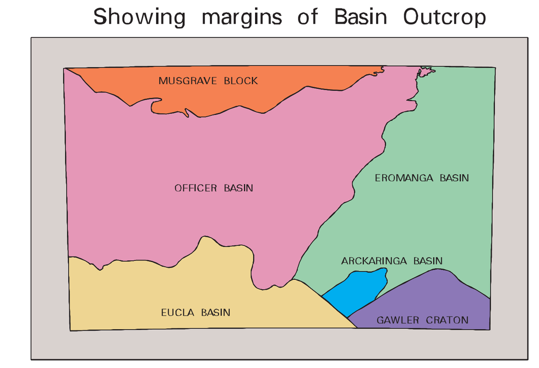
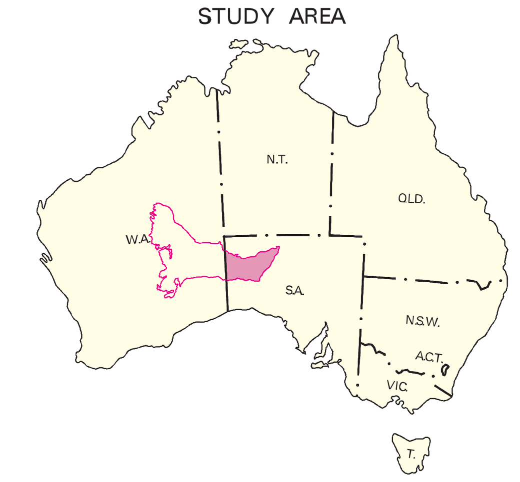


GEOLOGICAL PROVINCES
Showing margins of Basin Outcrop



STUDY AREA



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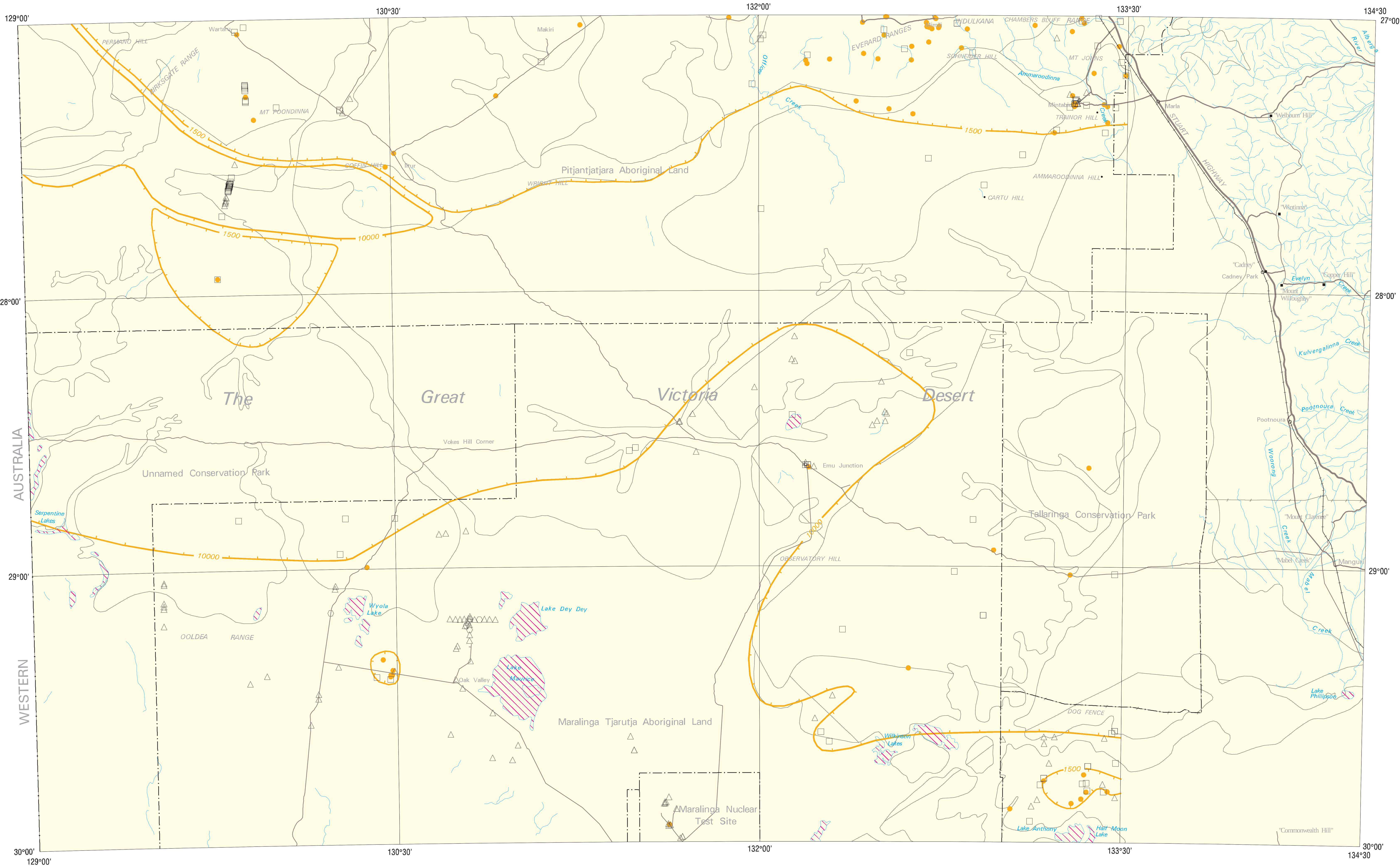
MINES AND ENERGY SOUTH AUSTRALIA

GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 9

Groundwater Systems

1995



OFFICER BASIN

SOUTH AUSTRALIA

Groundwater Salinity

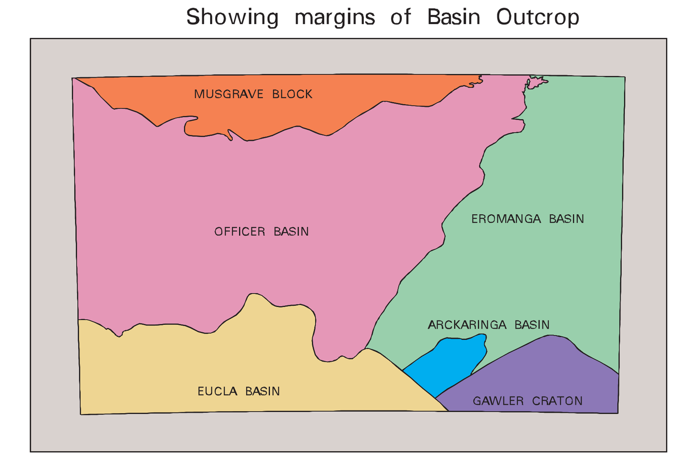
by J.E.Lau, A.R.Dodds
P.Tewkesbury and G.Jacobson

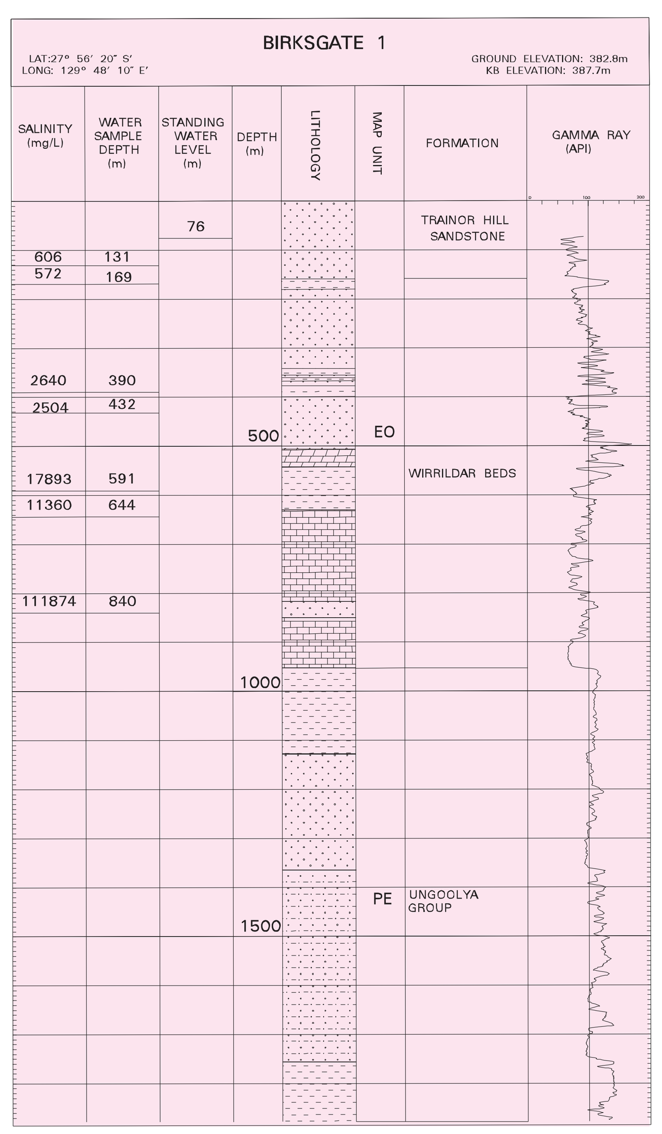
Scale 1:1 000 000

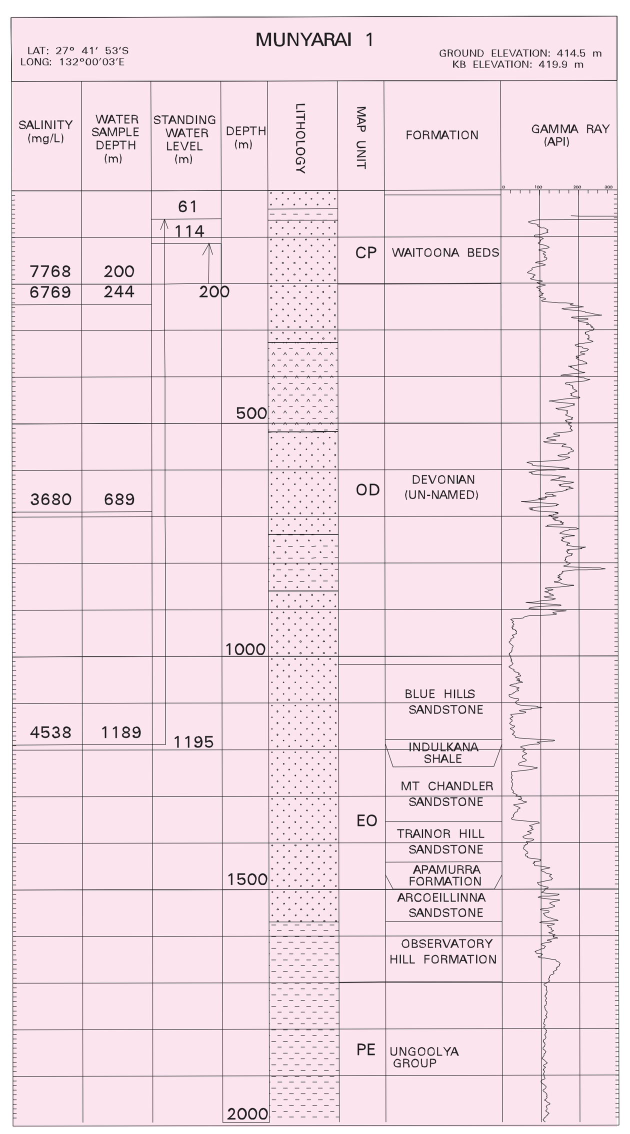
Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E

- Bore with fresh water (<1500 mg/L total dissolved solids)
- Bore with brackish water (1500-10 000 mg/L total dissolved solids)
- Bore with saline water (10 000 - 100 000 mg/L total dissolved solids)
- Bore with hypersaline water >100 000 mg/L total dissolved solids
- Generalised isohaline 1500 mg/L (ticks point to lower salinity)
- Generalised isohaline 10 000 mg/L (ticks point to lower salinity)
- Geological boundary (see Plate 9)
- Road
- Mintabie Town
- River intermittent
- Salt lake (playa) - hypersaline groundwater discharge >100 000 mg/L total dissolved solids

GEOLOGICAL PROVINCES
Showing margins of Basin Outcrop







In the Officer Basin mean annual rainfall varies from only 150mm in the south to 200mm in the northern ranges. Even then it is unreliable with no distinct seasonal pattern. Mean annual evaporation ranges from 3000mm in the south to 3600mm in the north (Laut & others,1977). Groundwater is therefore a valuable resource - in the west for new aboriginal outstations like Oak Valley (Davis & Kirke, 1991) and in the north east for the pastoral industry and the opal-mining township of Mintabie.

The **groundwater systems map** (Plate 9) uses new groundwater data from recent seismic investigations (Aldam, 1994; Plates 6 & 7) and previous hydrogeological reports. The broad units adopted within the basin are based mainly on seismic boundaries and structure. An inset shows their relationship to the stratigraphy. The adjoining groundwater provinces are shown notionally on the map.

The potentiometric surface is based on available surveyed elevations - of bores, of playas and playa deposits (which are assumed to be current groundwater discharge features), and of a floodout and a high-level lake (which are assumed to be groundwater recharge features at or above the regional watertable).

Potentiometric contours have been drawn as continuous across all hydrogeological units on the mapface although it is likely that deposits in some of the palaeodrainages (T) may be above the regional watertable and unsaturated. Contours have been continued to the West Australian border to join those mapped by Commander (1991). The Precambrian unit (pE) is considered as hydrogeological basement with little groundwater flow through it.

Groundwater flows south to discharge at the surface in playa complexes and at depth to the Eucla Basin beneath the Ooldea Range. Groundwater discharges from the Officer Basin in a broad zone across the basin's southern platform. In this zone groundwater storage in the Cambrian-Ordovician unit is reduced both by stratigraphic thinning and by decreasing porosity and permeability toward the base of the sequence in formations such as the Observatory Hill Formation and the Wirrildar Beds. The Wirrildar Beds where they were intersected by shotholes on Seismic Lines 5 and 6 are impermeable mudstones which project above the potentiometric surface; they are therefore considered to act as a partial barrier to horizontal groundwater flow from the Officer Basin to the Eucla Basin.

Connected surface drainage is absent in the Officer Basin today. Streams such as Officer Creek in the north and unnamed creeks in the northeast, which are well-established on the adjoining Musgrave Block and the Bulldog Shale of the Eromanga Basin respectively, disappear at the basin margin under the influence of higher porosity and permeability and lower watertables in the Palaeozoic sandstones. (The surveyed elevation of the Officer Creek "floodout" is shown as a maximum elevation of the potentiometric surface.)

The palaeodrainage system formed in the Eocene during the maximum marine transgression of the Eucla Basin. The Hampton Sandstone and the Pidinga Formation were deposited at this time. The palaeodrainages were reactivated during the Miocene-Pliocene transgression of the Eucla Basin when the Garford Formation formed (Benbow, 1993). Both periods of deposition imply watertables in the palaeodrainages at or above the current ground surface. At the southern end of the Lindsay Palaeochannel, west of Emu Junction, the watertable today is some 40m below ground level (Plate 7). A decline in water level of at least 40m since the Pliocene is therefore indicated.

The **groundwater salinity map** (Plate 10) summarises salinities in bores, seismic shotholes and salt lakes for the Officer Basin and environs west of longitude 133 degrees 30 minutes east. A cutoff value of 1500 mg/L total dissolved solids is used to indicate "fresh" or "potable" water. However most fresh waters analysed for nitrate and fluoride contain concentrations above the World Health Organisation limits for drinking water of 45 mg/L nitrate and 1.5 mg/L fluoride respectively (Read,1986; 1988; 1990).

In the South Australian portion of the Officer Basin significant thicknesses of fresh water have so far been found only on the northern margin at Birksgate 1 and in a broad area centred on Mintabie (Read, 1990). This suggests that recharge to the basin has occurred mainly in this area and that groundwater salinity should increase down flow.

In Birksgate 1, relatively fresh water of salinity less than 2500 mg/L occurs in the sandstone-rich upper part of the Officer Basin sequence - in the Trainor Hill Sandstone and the upper Wirrildar Beds - to a depth of 432m. In the underlying Wirrildar Beds, in less permeable shale and carbonate, salinity increases markedly to 111874 mg/L at a depth of 840m.

In the Western Australia portion of the Officer Basin, fresh groundwater is relatively widespread and not confined to the basin margins (Commander, 1991). Commander (personal communication, 18/11/94) believes that recharge occurs on the interfluves of palaeodrainages and that most bores sited on interfluves and away from playas ought to obtain fresh water.

The Western Australian occurrences of fresh water appear to be in the Permian Paterson Formation, perhaps in favourable glacial alluvial fan environments (Iasky, 1990). Recharge conditions may be significantly different and less favourable in the older sequences of the South Australian portion of the basin. However, surface water divides between palaeochannels (mapped in detail on Plate 8) are recommended bore sites until proved otherwise. In the mean time the salinity contours adopted are the more conservative ones but the regional recharge zone shown on the cross-section (Plate 9) is tentatively extended to include all of the sandstone plateau and the possibility of interfluve recharge.

In the regional discharge zone, fragile thin lenses of fresh groundwater occur in one bore at the Maralinga Nuclear Test Site (Morris & others, 1989), in the bores west of Oak Valley, and at Waldana Well, a traditional Aboriginal well with a salinity of 1800 mg/L (Read, 1988). On regional geological maps, all three are associated with calcrete or limestone outcrops and these hard surfaces may concentrate surface runoff for subsequent recharge to the aquifer below. At Oak Valley swamps were sometimes useful indicators of recharge to aquifers in the Cambrian-Ordovician unit below them (Read, 1988).

The only indication of a confined regional aquifer like the Mereenie Sandstone in the Amadeus Basin is in Munyarai 1. Groundwater salinity decreases from 7768 mg/L in a Carboniferous-Permian aquifer to 3680 mg/L and 4538 mg/L respectively in underlying Ordovician-Devonian aquifers. Although the interval 920-1350m resembles the Mereenie Sandstone lithologically and on gamma ray logs, its salinity of 4538mg/L is far higher than the 1500mg/L maximum of most of the Mereenie Sandstone.

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Groundwater Salinity (1:1 000 000)
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

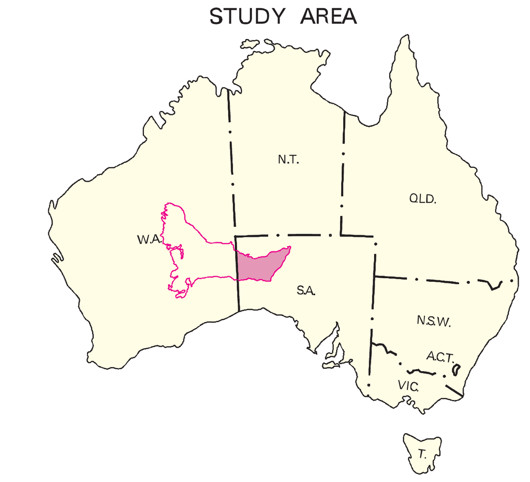
Geology by M.C.Benbow, D.I.Gravestock, G.W.Krieg, MESA and J.F.Lindsay, AGSO
Compiled 1994 by J.E.Lau & G.Jacobson AGSO,A.R.Dodds & P.Tewkesbury MESA
Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
Data processing by K.Reine and E.Bleys, AGSO using Petrosys software
Cartography by V.Ashby, AGSO
Produced by AGSO Cartographic Services Unit using ArcInfo software

Topographic detail based on information supplied by the Department of Environment and Natural Resources, South Australia.

Parks and Reserves supplied by Department of Housing and Urban Development, South Australia.

Published jointly by the Australian Geological Survey Organisation, Canberra, Australia and the Department of Mines and Energy, South Australia, Adelaide, as part of the National Geoscience Mapping Accord

STUDY AREA



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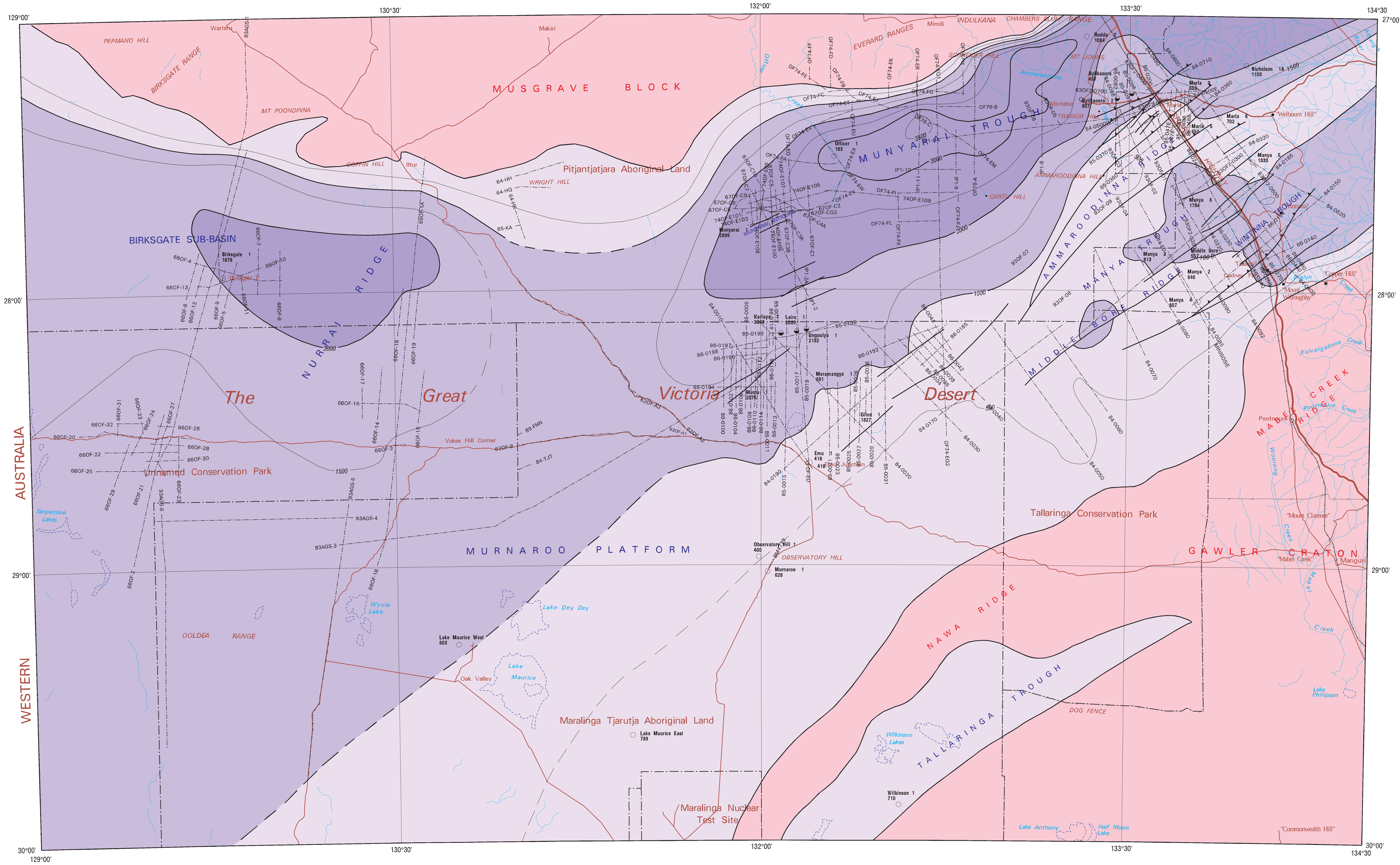

OFFICER BASIN

SOUTH AUSTRALIA

Seismic and drillhole data base

by J.Lindsay, J.Leven

Scale 1:1 000 000

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

Index contour with value

Petroleum exploration well with name and depth

Petroleum exploration well with show of oil

Seismic line

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

Compiled 1990-1994 by J.F.Lindsay, J.H.Leven, AGSO
Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
Data processing by K.Reine, AGSO using Petrosys software
Cartography by A.J.Retter, AGSO
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It is recommended that this map be referred to as:
Lindsay,J.F., Leven,L.H., 1995 -
Seismic and Drillhole Data Base (1:1 000 000)
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

LOCALITY PLAN

The Officer Basin underlies one of the more arid and remote regions of Australia and is perhaps the most poorly understood of the continent's intracratonic basins. Neoproterozoic and mid-Palaeozoic rocks, which form the bulk of the basin fill, are very poorly exposed due largely to widespread Pleistocene and Holocene sand dune cover. As is the case in many intracratonic basins in Australia, hydrocarbon prospectivity is perceived to be limited, and in combination with access and logistical difficulty the basin has been seen as a high risk prospect. As a consequence the available seismic database is small and mostly confined to the east, close to the Stuart Highway and the township of Marla.

A number of relatively small scale seismic surveys were carried out in the basin beginning in 1966. A total of approximately 8100 kilometres are available although data quality is variable in the earlier surveys. The Serpentine Lakes seismic survey was an early Vibroseis survey conducted by Continental Oil Company (Conoco) in 1966. More recent activity in the eastern Officer Basin, includes seismic data recorded by Shell in 1974, the Department of Mines and Energy, South Australia (MESA) in 1974 and 1978, Comalco from 1983 to 1986 (Stainton & others, 1988) and Amoco in 1987.

Comalco Aluminium Limited carried out a seismic survey between 1984 and 1986, shooting 2613 km of data and drilling five cored wells (Cucuzza & Akerman 1984; Cucuzza & others, 1984; Hibburt, 1990; Thomas, 1990). Amoco (1987) gathered a further 235 km of seismic data, principally to tie Munyarai #1 with Ungoolya #1 and so resolve the age of the Munyarai #1 succession. The most recent seismic includes a survey across the central Officer Basin carried out by the Australian Geological Survey Organisation (AGSO) and a survey sponsored by MESA in the Marla overthrust area both during 1993. The AGSO survey involved 550 km of data gathered as part of the National Geoscience Mapping Accord (NGMA) using a dynamite source whilst the MESA survey recorded 378 km of vibroseis data as part of the South Australian Exploration Initiative (SAEI) (Mackie & Gravestock, 1993; Mackie, 1994; Gravestock & Lindsay, 1994).

Only 30 wells have been drilled to depths greater than 500 m in the South Australian part of the basin. Most are to the extreme east with only one well drilled close to the Western Australian border (Birksgate #1). The petroleum well (Emu #1) was drilled by Exoil in 1963 but to date only eight wells have been petroleum wildcats. Five of these were drilled by Comalco but by far the largest number drilled by that company were targeted towards the evaporite mineral trona. It is in these drillholes in the Marla area that the majority of oil shows have been recorded (Stainton & others, 1988). Other company drillholes have been directed towards base metal or uranium exploration and a number of stratigraphic wells, including the oil discovery Byilkaoora #1, were drilled by MESA between 1978 and 1987.

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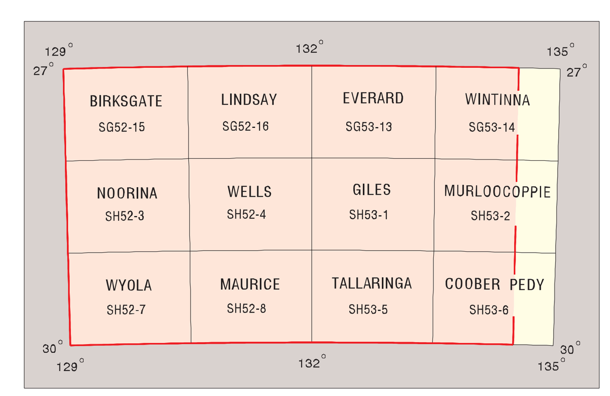
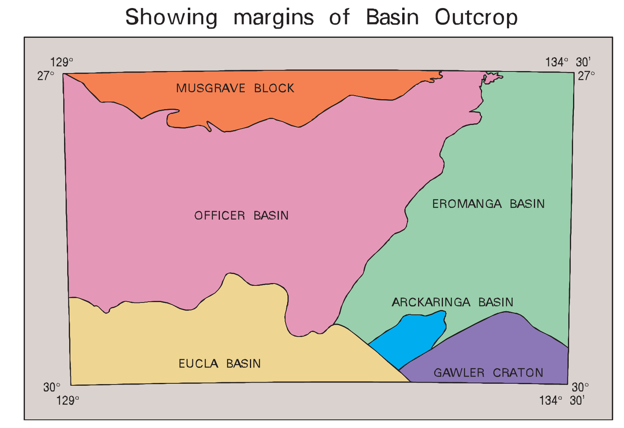
INDEX TO 1:250 000 MAPS



GEOLOGICAL PROVINCES

Showing margins of Basin Outcrop



STUDY AREA

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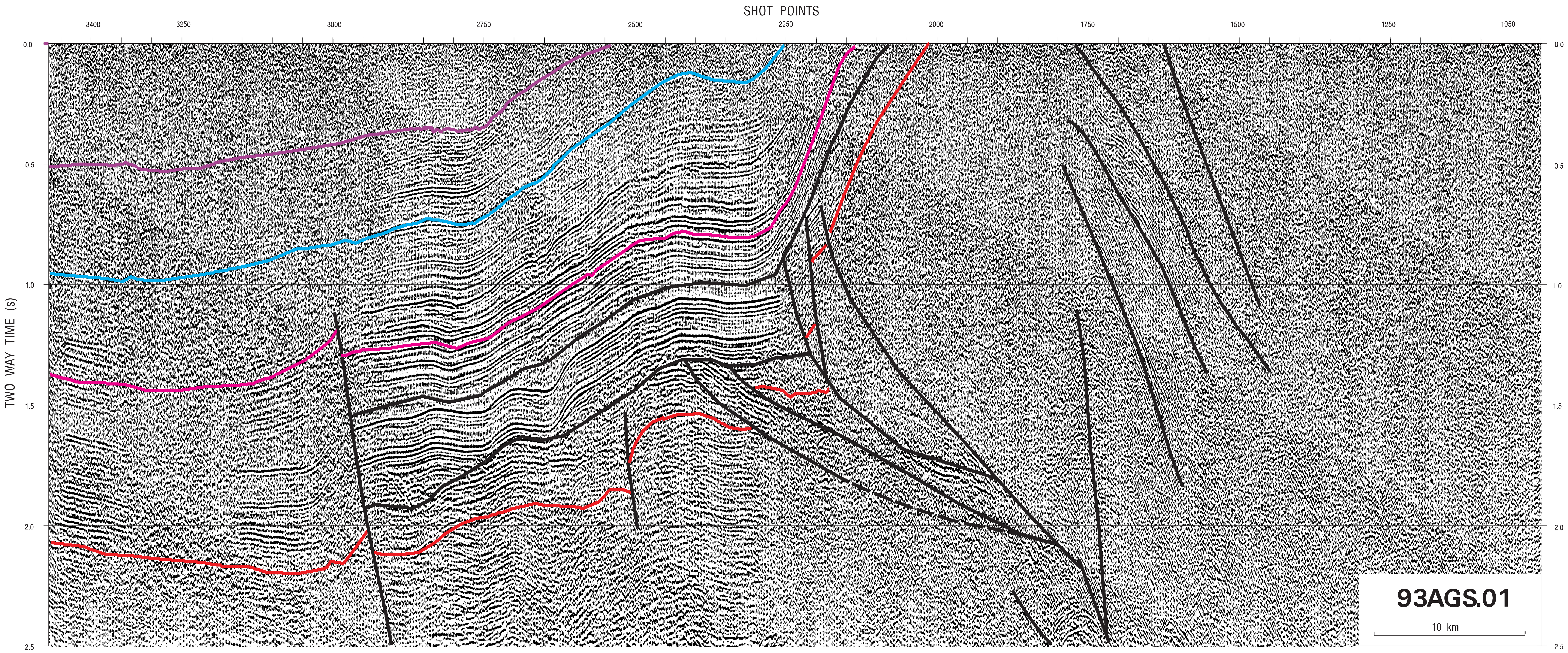
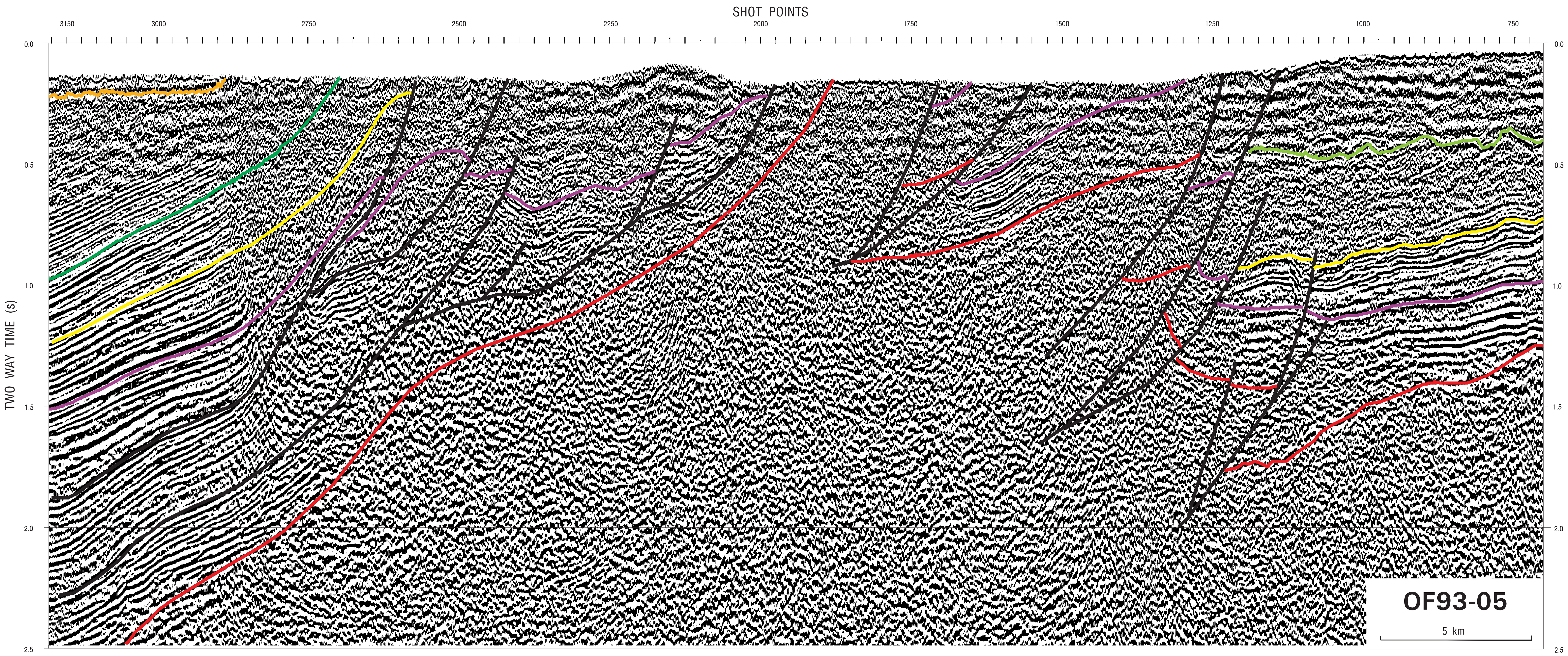
MINES AND ENERGY SOUTH AUSTRALIA



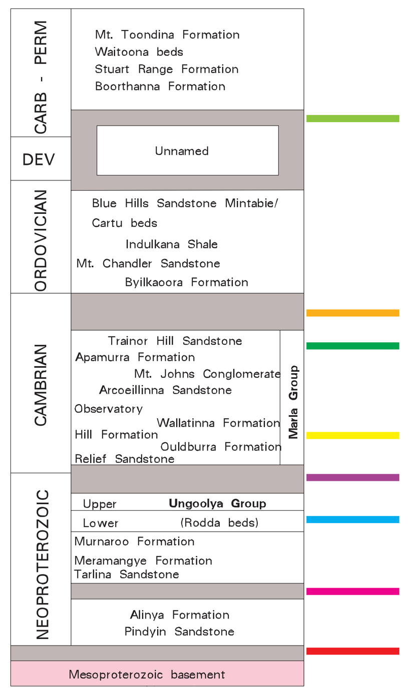


OFFICER BASIN

SOUTH AUSTRALIA

Key Seismic Sections

by J.Leven & others



More than 900 km of seismic data were recorded in the Officer Basin in 1993 (Gravestock & Lindsay, 1994). The surveys, recorded in the dune-covered Great Victorian Desert in South Australia comprise 550 km of 10-fold data using a dynamite source acquired as part of the National Geoscience Mapping Accord (NGMA) by the Australian Geological Survey Organisation and 378 km of 120-fold vibroseis data acquired for the Mines & Energy Department as part of the South Australian Exploration Initiative (SAEI). The NGMA transect, in two parts, was the first in the barely explored central and southern Officer Basin. The SAEI grid linked seismic acquired in the mid-1980s by Comalco and Amoco in the eastern Officer Basin. A further 140 km of Comalco seismic data (mainly weight drop) were reprocessed to the same standard.

The results of the seismic and associated geological and geophysical studies: 1) confirm thrust faulting (Alice Springs Orogeny) along the structural northern basin margin (93AGS.01), the thrusts propagating south within as well as beneath the sedimentary cover, 2) indicate 6 km or more of Neoproterozoic sediment in the Birksgate sub-basin, 3) indicate the southern Murnaroo Platform is unlikely to contain large structures, 4) strengthen biostratigraphic correlation with the Amadeus Basin and confirm the utility of acritarchs for Neoproterozoic zonation, and 5) indicate a potential sabkha-associated source rock near the base of the succession. The two seismic lines presented here illustrate the complexities associated with thrusting along the basin's northern central margin (93AGS.01) and the Marla Thrust Zone (Gravestock & Lindsay, 1994).

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Edited by D.Palfreyman, AGSO
Cartography by A.J.Retter, AGSO
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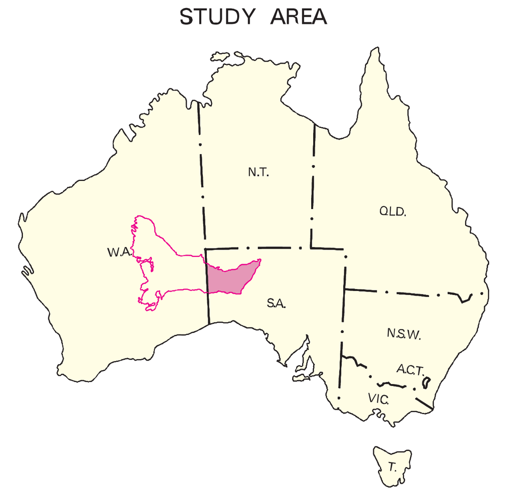
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

STUDY AREA



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AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 12

Key Seismic Sections

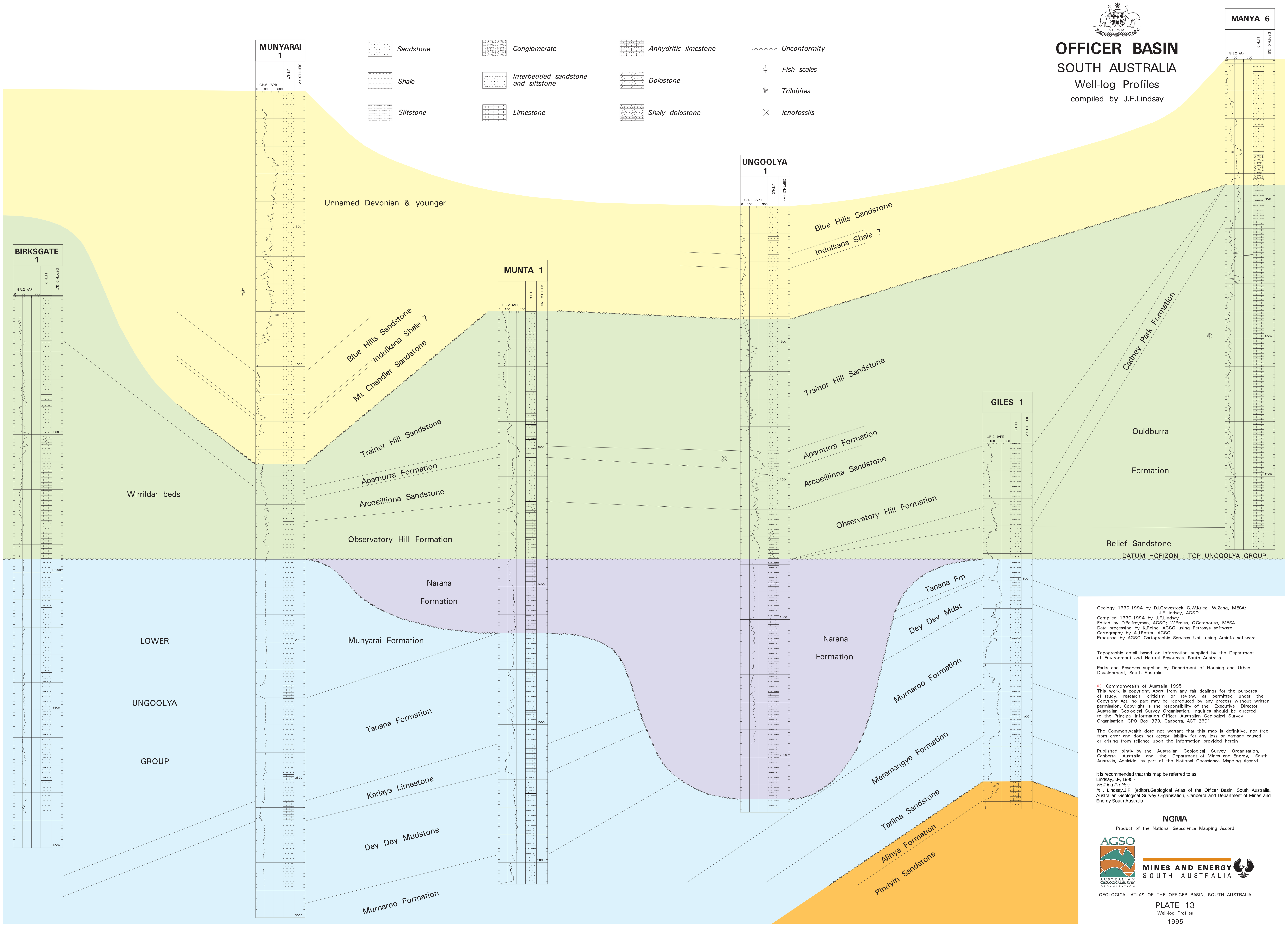
1995

OFFICER BASIN

SOUTH AUSTRALIA

Well-log Profiles

compiled by J.F.Lindsay



Geology 1990-1994 by D.I.Gravestock, G.W.Krieg, W.Zang, MESA; J.F.Lindsay, AGSO
Compiled 1990-1994 by J.F.Lindsay
Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
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Lindsay,J.F, 1995 -
Well-log Profiles
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AGSO

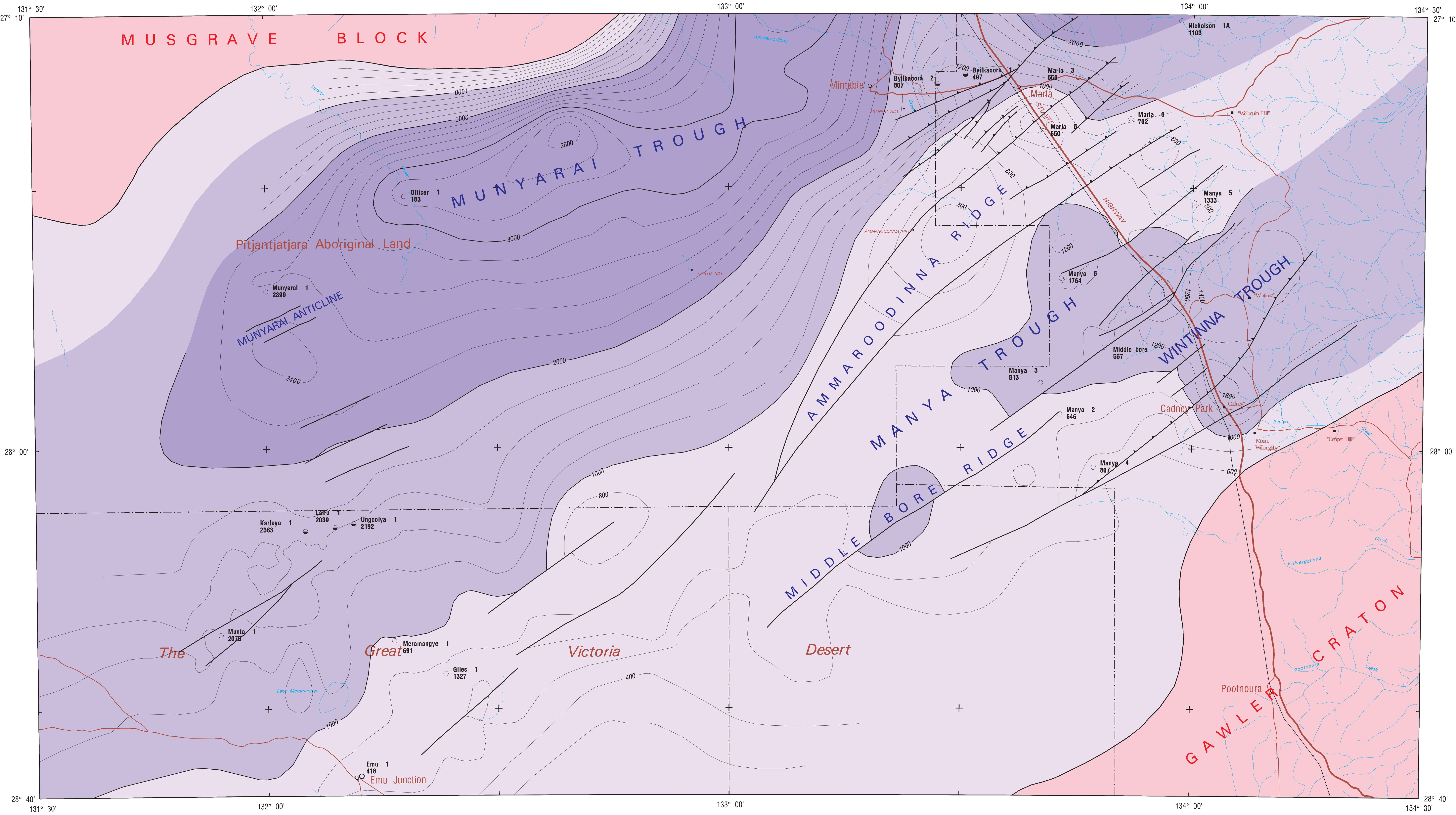
MINES AND ENERGY SOUTH AUSTRALIA

GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 13

Well-log Profiles

1995



OFFICER BASIN

SOUTH AUSTRALIA

Depth to Mesoproterozoic Crystalline Basement

by J.F.Lindsay

Scale 1:500 000

10 0 10 20 30 40 50 kilometres

Lambert Conformal Projection

Standard parallels 27°15'S 30°15'S

Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

1000 *Index contour with value (ms)*

Officer 1 183 *Petroleum exploration well with name and depth*

Petroleum exploration well with show of oil

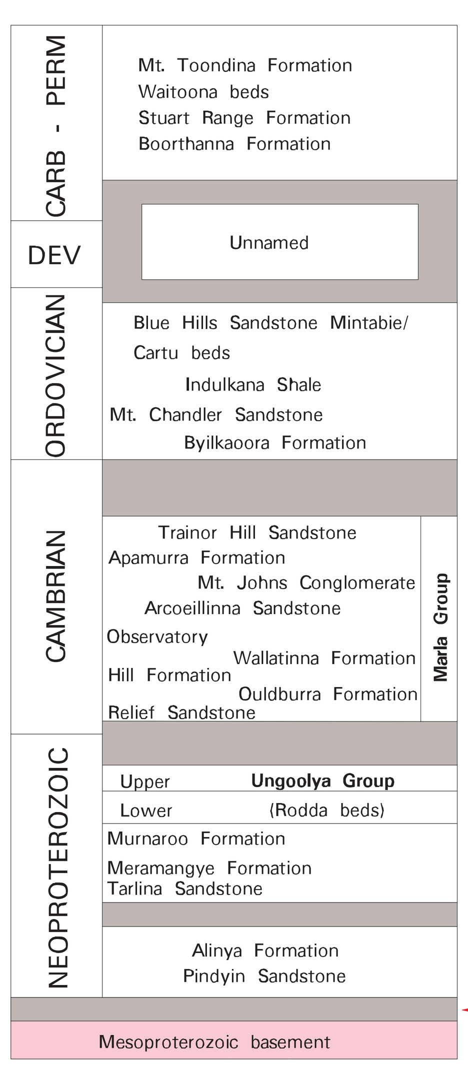
Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms



Time structure contours of the crystalline basement unconformity beneath the eastern Officer Basin succession outline the basin's general form. Like the Amadeus, Georgina and Ngalia Basins, the Officer Basin has one sharply defined margin, the northern margin, which is closely paralleled by an arcuate series of deep sub-basins which shallow gradually to the south toward the opposite margin to merge with a broad shallow platform, the Murnaroo Platform (Lindsay & others, 1987; Leven & Lindsay, 1992). The steep northern margin of the basin is a homoclinal upturn, or roll back, resulting from tectonic activity during the Mid-Palaeozoic Alice Springs Orogeny on a northerly-dipping basement thrust complex (Lindsay & Leven, in prep.). This margin is thus structural and the original northerly extent of the basin unknown.

The two sub-basins; the Munyarai Trough, which appears on this map, and the Birksgate Sub-basin further to the west are separated by the Nurrai Ridge a clearly defined magnetic and gravity high (see Plates 3, 29 & 30). Recent seismic surveys show that the Nurrai Ridge has no geomorphic form on the basement unconformity at least at its southern extreme (Lindsay & Leven, in prep.). This implies that the boundary between the two sub-basins lies further east and is defined by the ridge extending north from the Munyarai Anticline. If this is true the two sub-basins did not become separate entities until the start of the Petermann Ranges Orogeny in the late Marinoan.

The Birksgate Sub-basin is separated from the Murnaroo Platform to the south by a shallow ramp (slope 0.3 degrees) which appears to have developed in response to broad regional subsidence early in basin evolution rather than late-stage thrusting (Lindsay & Leven, in prep.). The sedimentary succession over the Murnaroo Platform gradually thins to the south ultimately onlapping the Coompana Block. The Munyarai Trough, which reaches a depth of approximately 3.4 s two-way-time, ramps southward more steeply onlapping a major ridge, the Ammaroodinna Ridge (Stainton & others, 1988), which separates it from the shallow elongate northeast-southwest-trending Manya Trough. Further south from the Manya Trough the basin thins onto the edge of the Gawler Craton, with a series of troughs and ridges that parallel the craton boundary (Middle Bore Ridge, Nawa Ridge and Tallaringa Trough).

The Ammaroodinna Ridge, a shallow Proterozoic basement ridge which is exposed as the Ammaroodinna Inlier, extends southwest-northeast at a depth of approximately 1.0s TWT and then plunges beneath the Manya Trough. It is a flat to undulating structure with strong aeromagnetic and gravity expression. Reactivated deep-seated thrust faults underlie the Ammaroodinna Ridge and link up with thrust faults in the Marla Overthrust Zone to the northeast (Mackie, 1994). The Ammaroodinna Inlier (Krieg, 1973), a small basement exposure of schist, gneiss and granitoid rock, is situated on a thrust slice south of the Musgrave Block in the western Marla Overthrust Zone. K-Ar ages of 1104 Ma and Rb-Sr ages of 1050 and 973 Ma suggest that basement in this area is Mesoproterozoic (Krieg, 1972a; 1972b, 1993; Webb, 1985). The Yoolperlunna Inlier, 25 km north of Marla, consists of partly mylonitised granite gneiss intruded by small granitoid dykes (Freeman & Rankin, in prep.).

Middle Bore Ridge is a major northeast-southwest trending basement ridge that separates the Manya and Wintinna Troughs (Plate 3). The ridge consists of a series of en echelon 'flower structures'. Strike-slip movement is expected but offset is difficult to determine at present. The ridge appears to be underlain by Proterozoic gneiss and schist (Mackie, 1994).

Immediately east of the Munyarai Trough is a zone of intense overthrusting, the Marla Overthrust Zone (Mackie & Gravestock, 1993). The zone is separated from the Munyarai Trough by a major strike-slip/reverse fault. The predominant direction of stress is from the northwest with a series of overriding ramp thrusts. Sedimentary rocks in the zone are mainly Cambrian overlying Neoproterozoic units. Cambrian strata are exposed at the surface indicating large vertical uplift and erosion. It is in this zone that the Byilkaoora and most Marla wells (eight with oil shows) have been drilled.

Basement exposed marginally to the eastern Officer Basin includes metamorphic and igneous rocks of the Archaean to Palaeoproterozoic Gawler Craton, the Precambrian Birksgate Complex and Musgrave Block. Palaeoproterozoic rocks within the northwest Gawler Craton comprise upper amphibolite to granulite facies gneisses and banded iron formation yielding a Rb-Sr minimum age of ~1700 Ma (Rankin & others, 1989; Parker & Daly, 1982; Parker & Lemon, 1982), however, the block had become stable by 1400 Ma (Webb, 1979). K-Ar ages on cores from Middle Bore Ridge suggest that the Coompana Block is Mesoproterozoic. The Mesoproterozoic Musgrave Block consists of gneiss, quartzite, acid to basic granulite rocks and the mafic to ultramafic Giles Intrusive Complex (Major & Conor, 1993). Basic dyke swarms are numerous with at least two phases of intrusion during the latter stages of the 1225-1075 Ma Musgravian Orogeny. East-west faults and shear zones were initiated at this time and were reactivated in the Late Neoproterozoic Petermann Ranges and mid-Palaeozoic Alice Springs Orogenies (Major & Conor, 1993).

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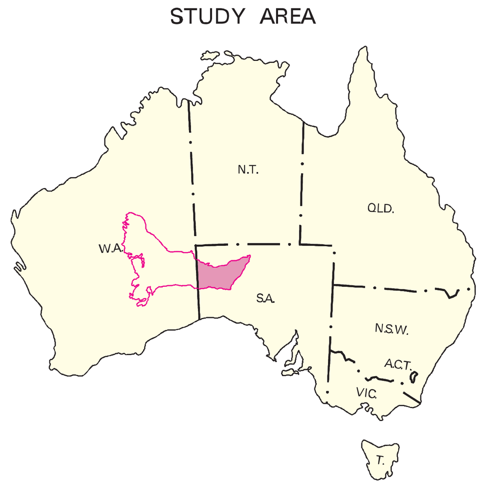
Lindsay,J.F, 1995 -
Depth to Mesoproterozoic Crystalline Basement (1:500 000)
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

STUDY AREA



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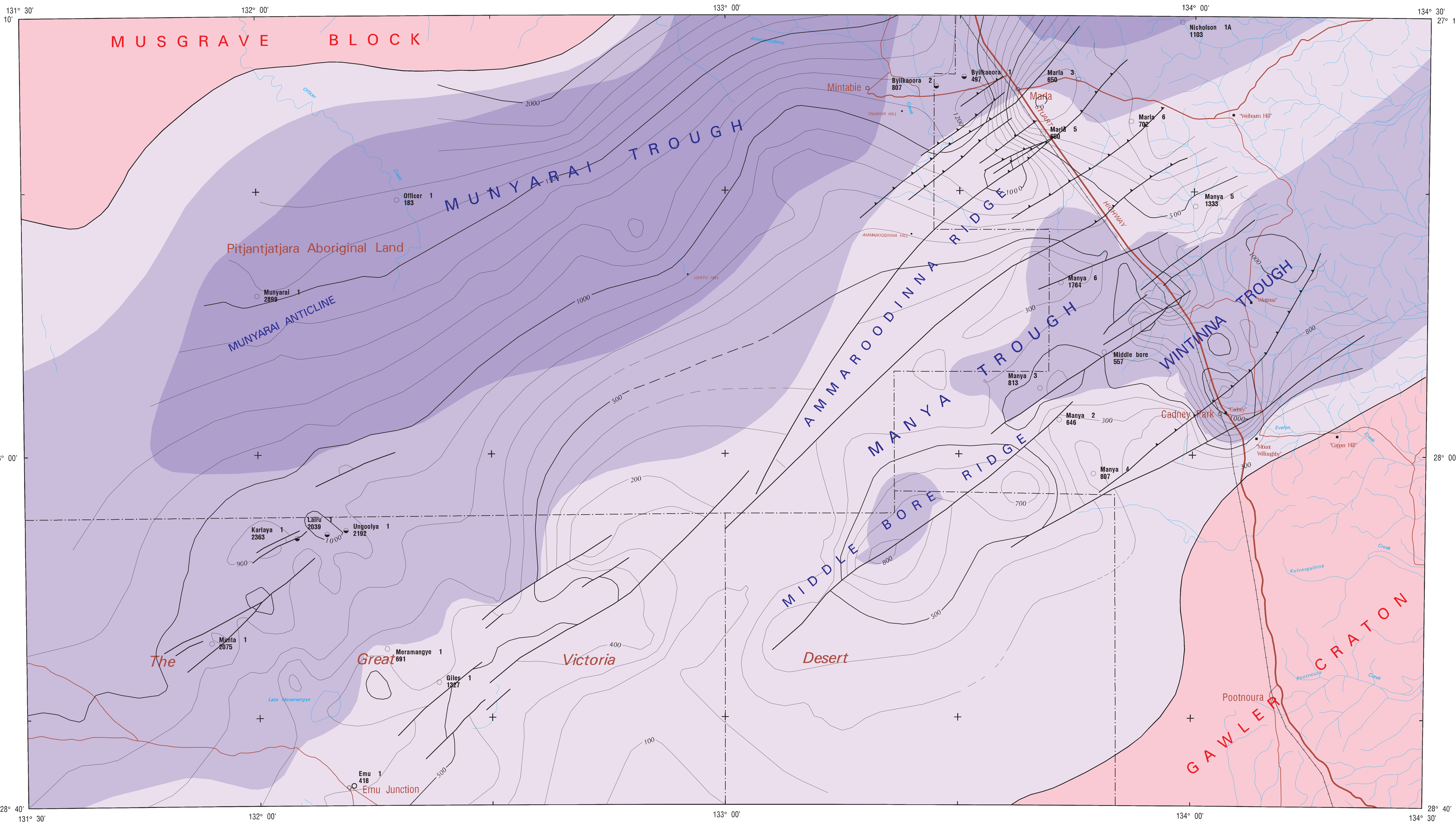
MINES AND ENERGY
SOUTH AUSTRALIA

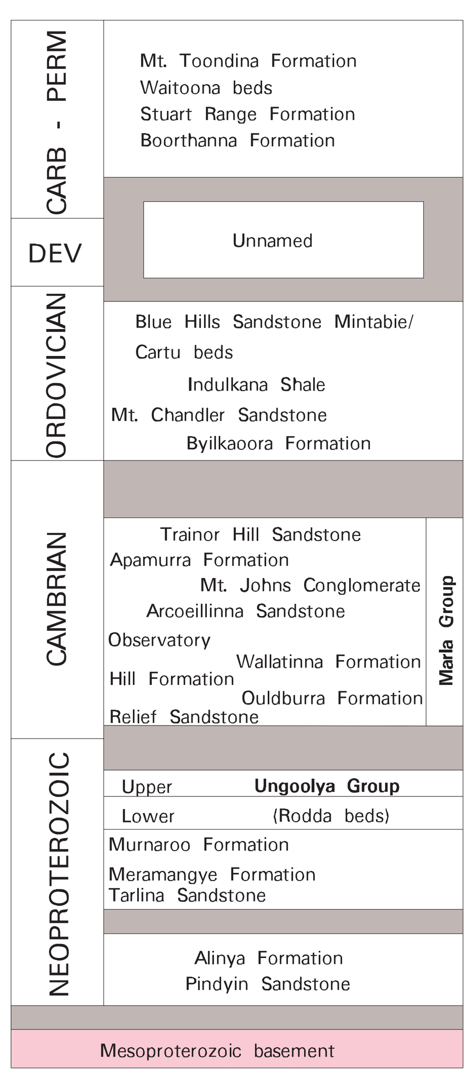
GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 14

Depth to Mesoproterozoic Crystalline Basement

1995





Overall more than half of the sedimentary fill of the eastern Officer Basin is Neoproterozoic in age (Brewer & others, 1987; Stainton & others, 1988; Sukanta, 1993; Gravestock & Lindsay, 1994). The succession forms a large-scale wedge that thickens towards the monoclinal northern margin of the basin suggesting that a considerable area of the basin that overlay the Musgrave Block to the north was removed by erosion following the Petermann Ranges, Delamarian and Alice Springs Orogenies (Lindsay & Leven, in prep.; Gravestock & Sansome, 1994).

Neoproterozoic sedimentation began in the Officer Basin at approximately 800 Ma in response to broad regional subsidence and commencement of rifting in the Adelaide Geosyncline (Preiss, 1987). The mechanism controlling the regional subsidence is not known with certainty but may relate to large scale crustal thinning, perhaps during the final stage of the assembly of the Proterozoic supercontinent (Lindsay & others, 1987). At least two other major tectonic events affected the creation of depositional space in the basin during the Neoproterozoic. In the Marinoan, following a long erosional hiatus, the basin again began to subside. Stacking patterns within the following sedimentary sequences suggest that the subsidence occurred in response to a thermal event resulting from local thinning of the crust. Finally, subsidence was slowed again by the localised effects of the Petermann Ranges Orogeny a compressional event affecting the northern Officer and southwestern Amadeus basins (Lindsay & Korsch, 1989, 1991; Lindsay & Leven, in prep.).

The combined effects of these events resulted in the accumulation of a sedimentary succession that reached thicknesses represented by more than 2 s (TWT) in the north, thinning southward to 200 ms over the Ammaroodinna Ridge. Local thickening, indicated by closed isochrons around the fault-controlled highs, resulted from flow of evaporite units within the Alinya Formation which began shortly after its deposition and continued throughout the Neoproterozoic (see Plates 18, 19, 20, 23 and 25). The development of salt structures in the Amadeus Basin followed a very similar pattern to those of the Officer Basin (Lindsay, 1987).

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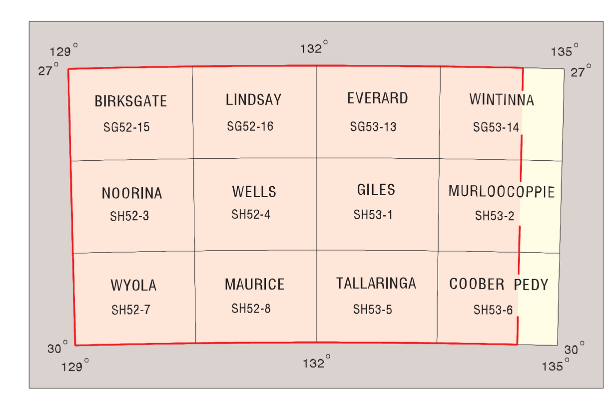
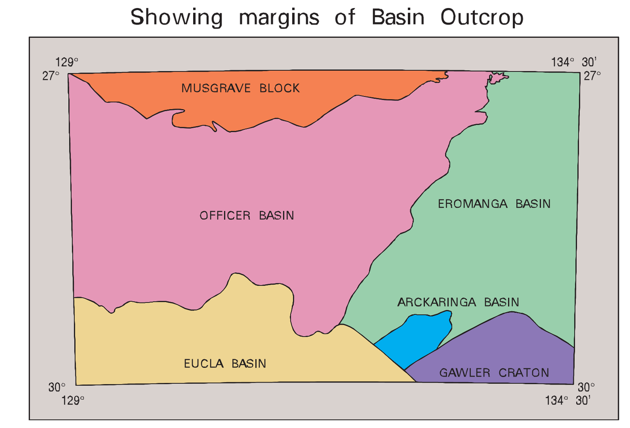
INDEX TO 1:250 000 MAPS



GEOLOGICAL PROVINCES

Showing margins of Basin Outcrop



OFFICER BASIN

SOUTH AUSTRALIA

Isochron of Neoproterozoic Succession

by J.F.Lindsay

Scale 1:500 000

10 0 10 20 30 40 50 kilometres

Lambert Conformal Projection

Standard parallels 27°15'S 30°15'S

Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

1000 *Index contour with value (ms)*

Officer 1 183 *Petroleum exploration well with name and depth*

Petroleum exploration well with show of oil

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

Compiled 1990-1994 by J.F.Lindsay, AGSO
Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
Data processing by K.Reine, AGSO using Petrosys software
Cartography by A.J.Retter, AGSO
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In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

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MINES AND ENERGY SOUTH AUSTRALIA

GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

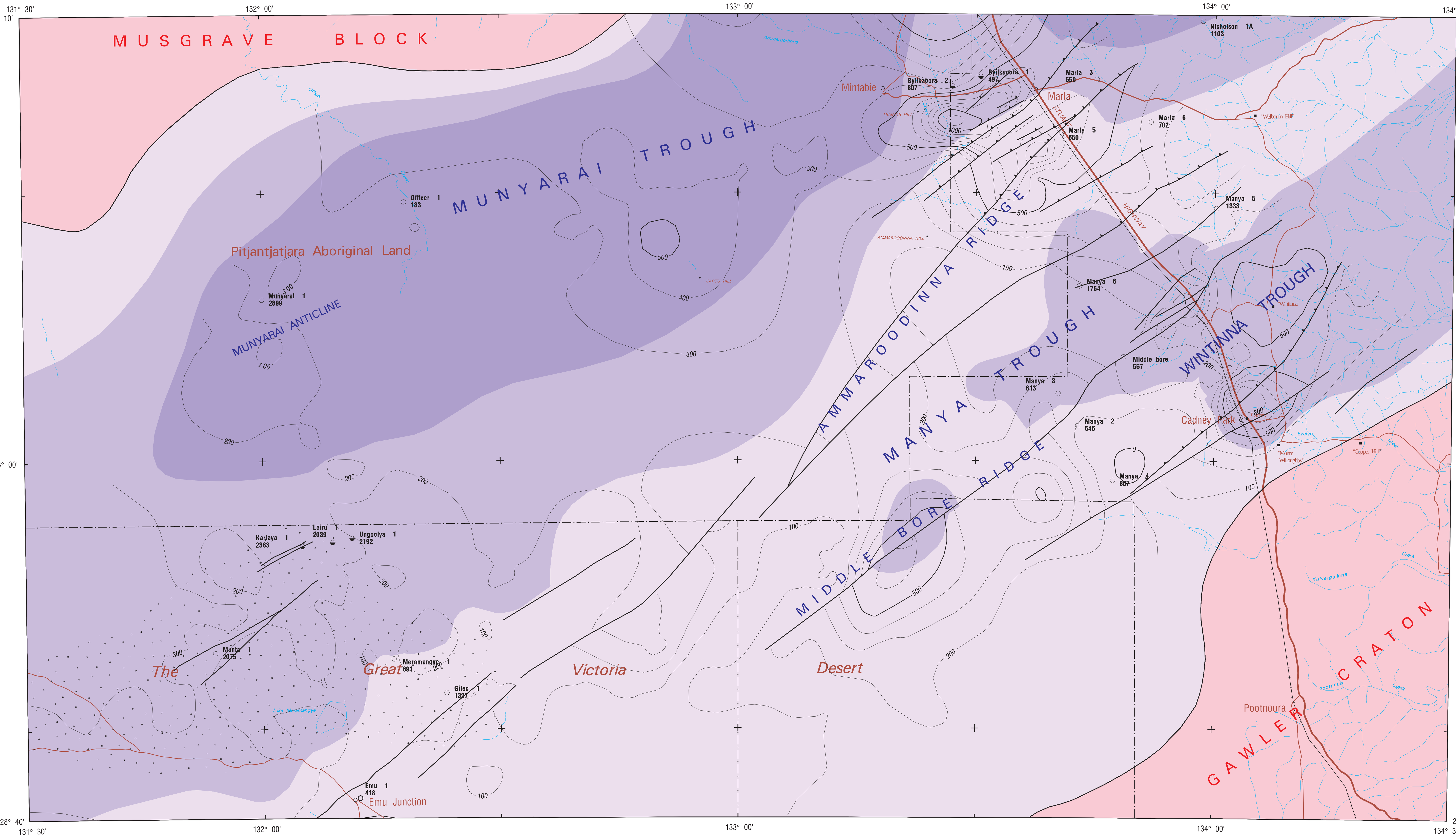
PLATE 15

Isochron of Neoproterozoic Succession

1995

OFFICER BASIN
SOUTH AUSTRALIA
Isochron of Willouran Succession

by J.F.Lindsay



Scale 1:500 000

10 0 10 20 30 40 50 kilometres

Lambert Conformal Projection

Standard parallels 27°15'S 30°15'S

Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

1000 Index contour with value (ms)

Officer 1 183 — Petroleum exploration well with name and depth

Petroleum exploration well with show of oil

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

Salt collapse

Compiled 1990-1994 by J.F.Lindsay, AGSO
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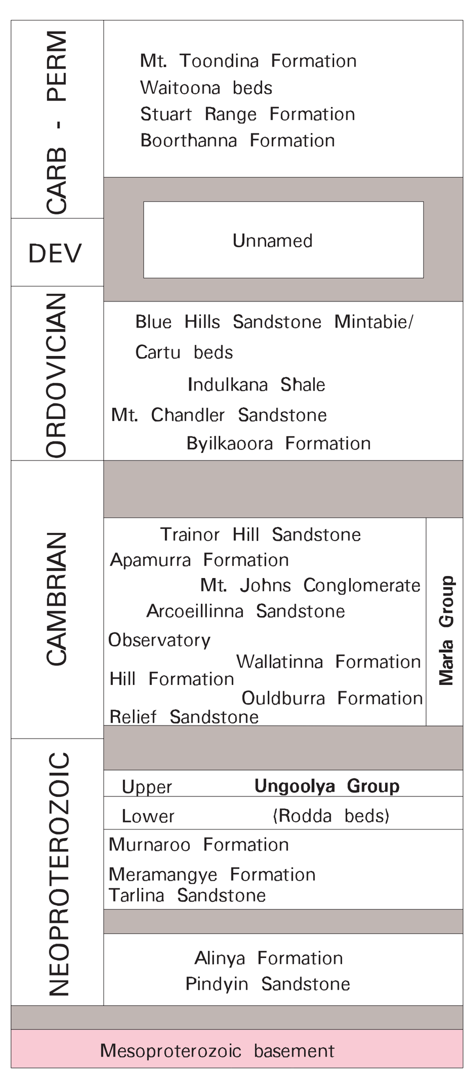

The Willouran rocks of the eastern Officer Basin form arcuate outcrops along to the northern basin margin, however, the Pindyin Sandstone and Alinya Formation can only be identified with certainty in Giles #1, 300 km to the southeast on the Murnaroo Platform (Major, 1973; Zang, in prep.). Here they comprise an aeolian-fluvial and evaporitic sabkha suite up to 200m thick. The Pindyin Sandstone is the oldest known unit in the Officer Basin and is seen to begin with a basal conglomerate of rounded quartz pebbles resting on the older basement complex (Major, 1973). The unit is lithologically very similar to the Heavitree Quartzite in the Amadeus Basin and consists of light coloured medium- to coarse-grained, flaggy quartzite and sandstone which is feldspathic in part. The sandstone is crossbedded with occasional flat-pebble clasts of clay (ripup clasts) and possibly synaeresis cracks in some units. Associated with the sandstone are thick green shale and siltstone interbeds (Major, 1973). The transition to the Alinya Formation is gradational to dolomitic anhydritic sandstone. At the extreme eastern end of the Officer Basin in the Manya area the Pindyin-Alinya suite is replaced by stromatolitic dolomite, redbeds and basalt. Preiss (1993) has suggested a correlation of these units with the Coominaree Dolomite and Cadlareena Volcanics in the Willouran rift system of the Adelaide Geosyncline (Ambrose & others, 1981). Similar tholeitiic basalt units occur in the Bitter Springs Formation of the Amadeus Basin (Lindsay & Korsch, 1989, 1991). Acritarchs from the sabkha facies of the Alinya Formation are correlated with the Bitter Springs Formation of the Amadeus Basin (Zang & McKirdy, 1993; Zang, in prep.). Equivalents in the western Officer Basin are the Townsend Quartzite, Browne and Lefroy beds (Townson, 1985).

Seismic data indicate that the basal Willouran succession is widespread; it forms the major décollement for thrust propagation and is the source of salt structures on the northwestern margin of the Murnaroo Platform. It is relatively uniform in thickness over large areas except where salt has been mobilised from the Alinya Formation to form pillows and walls (See Plates 16 and 17). The unit is typically 200 to 300 ms (TWT) thick except over the faulted area to the southeast along the Ammaroodinna Ridge where locally it reaches 600 to 1000 ms. The distinctive stacking pattern of the closely spaced reflectors within the two units and the uniformity of its thickness of the whole interval suggests that during Willouran time the region was subsiding slowly and uniformly over a very large area. A similar depositional history is recorded in other coeval intracratonic settings, such as the Amadeus Basin, suggesting that for a short time a single giant saline continental sag basin occupied much of the centre of the continent (Lindsay, 1987; Lindsay & Korsch, 1989, 1991; Walter & others, 1993). The extrusion of distinctive volcanic units in the Officer and Amadeus Basins and the Adelaide Geosyncline at about the same time almost certainly relates to basin mechanics and to the widespread thinning of the crust.

Salt tectonics were important in the evolution of the Australian intracratonic basins (Lindsay, 1987) and the Officer Basin is no exception. Salt movement has enhanced basin tectonics and basin evolution and, to some extent, controlled sedimentation throughout the basin's long history. The distribution of evaporites within the Alinya Formation is not uniform across the basin and they are present in units thick enough to flow only in the southeastern corner of the basin along the Ammaroodinna Ridge, extending westward beyond the limits of the map for approximately 60 km (Leven & Lindsay, 1992).

Evaporitic units within the Alinya Formation began to flow very soon after deposition as is evident from diapiric breccia of Torrensian or Sturtian age at the eastern end of the basin. Movement was sporadic throughout the Neoproterozoic as can be seen in subsequent isochrons (see Plates 18, 19, 20, 23, and 25). Broad salt-cored domal highs developed all along the Ammaroodinna Ridge to the margin of the Arckaringa Basin throughout the Neoproterozoic. At the same time a narrow diapiric wall developed parallel to the Ammaroodinna Ridge but a short distance to the northwest of the main high between Munta #1 and Ungoolya #1 wells (Thomas, 1990, Sukanta & others, 1991). The wall, which extends to the northeast for at least 45 km, is only 2 to 3 km in width and is not readily apparent in the widely spaced data portrayed on this plate. It is well developed at its western end where some parts of the wall have reached piercement stage. Eastward the wall reaches pillow stage and further east may simply merge with salt pillows of the main Ammaroodinna Ridge. Most of the salt structures in the eastern Officer Basin were reactivated during the latest Neoproterozoic to Cambrian Petermann Ranges Orogeny and the mid-Palaeozoic Alice Springs Orogeny. At least one major structure, the Munyarai Anticline, was initiated by reactivation of deep-seated older faults and subsequent salt movement into the zone above. This high played a major role in the evolution of the late Marinoan canyon surface (see Plate 24). Salt appears to have been very important in determining the geometry of the northern margin of the basin. Deeper thrust faults beneath the northern basin margin appear to have been redirected along the bottom of the basin fill and the strain absorbed in salt movement rather than disrupting the basin fill. The northern margin is thus a simple monocline rather than a thrust margin along much of its length (Lindsay & Leven, in prep.).

Prospectivity

The Willouran Pindyin Sandstone and the Alinya Formation form a reservoir and source rock couplet that offers some of the best untested hydrocarbon potential in the eastern Officer Basin. This megasequence, which has many similarities with its correlative in the Amadeus Basin (Heavitree Quartzite and Bitter Springs Formation), has only been investigated in the subsurface at one location, Giles #1 well. Total Organic Carbon (TOC) values in the Alinya Formation at Giles #l well (6 samples from 1238 to 1266m) range up to 0.62% (mean 0.36%) in the 35m thick sabkha facies. Organic richness is poor to fair, kerogen is gas-prone and maturation levels correspond to the oil generation window. Molecular biomarkers indicate eukaryotic algal and bacterial sources. The same molecular fossil assemblage is found in oil extracted from the much younger Murnaroo Formation and Relief Sandstone. Methylphenanthrene index measurements suggest these oils are relatively late expulsion products. The Alinya Formation, from one well alone, thus justifies further investigation as a potential source rock (Gravestock, 1994).

The most likely reservoir interval is the clean, aeolian Pindyin Sandstone at the base of the section in Giles #l (porosity 3.8 22.5%, mean 11.8%; permeability 0.04 - 1538 md, mean 48 md). The unit is widespread and the overlying evaporites of the Alinya Formation should form an effective seal over large areas of the basin.

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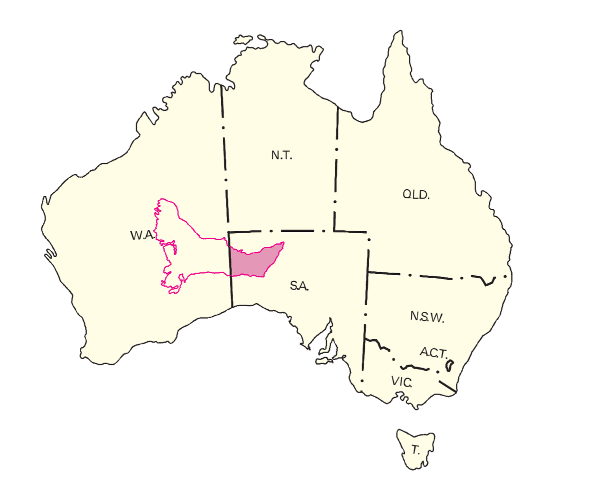

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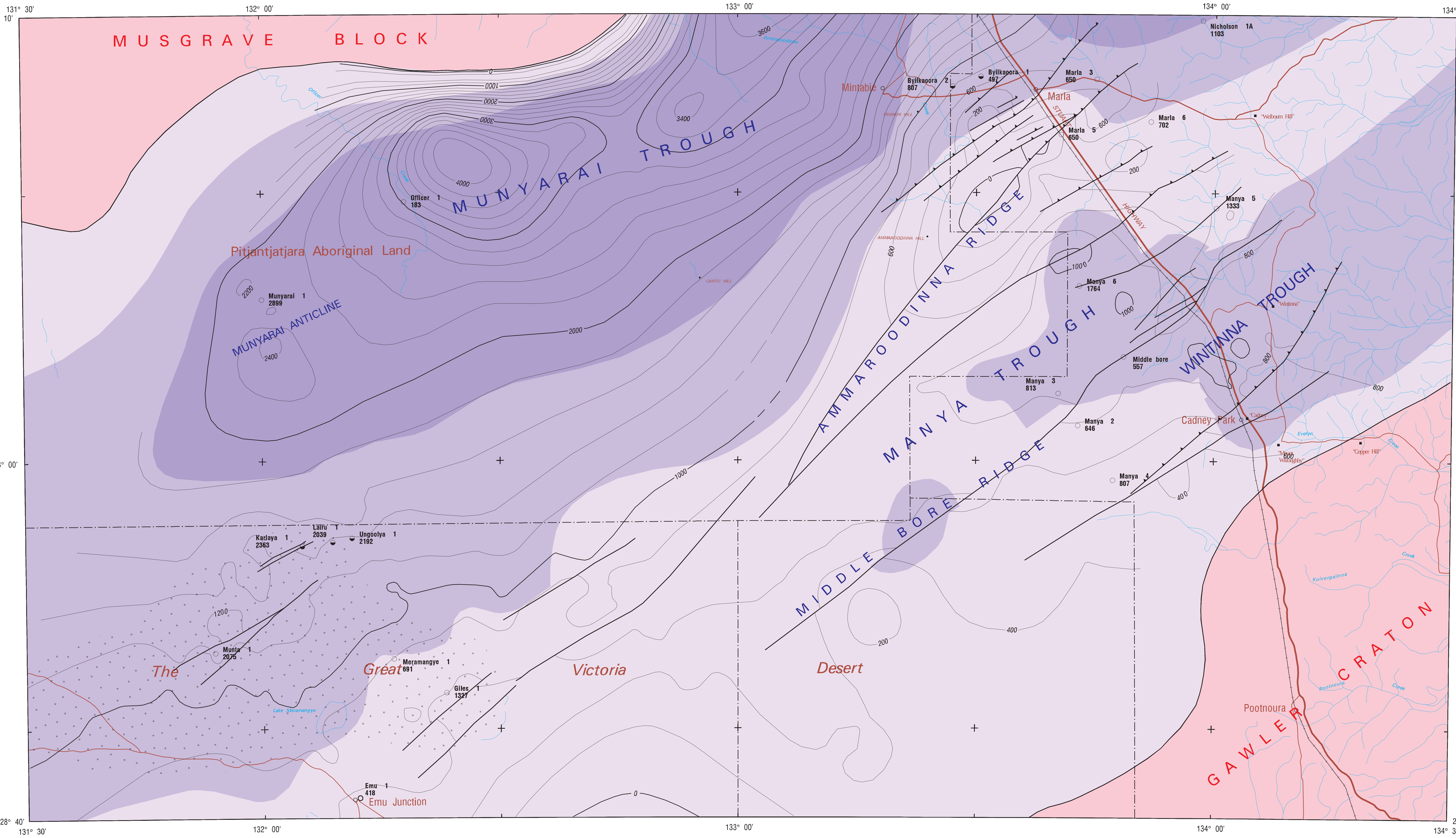

OFFICER BASIN

SOUTH AUSTRALIA

Depth to Top Willouran Sequence Boundary

by J.F.Lindsay

Scale 1:500 000

10 0 10 20 30 40 50 kilometres

Lambert Conformal Projection

Standard parallels 27°15'S 30°15'S

Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

1000 *Index contour with value (ms)*

Officer 1
183 *Petroleum exploration well with name and depth*

Petroleum exploration well with show of oil

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

Salt collapse

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CARB - PERM	Mt. Toondina Formation Waitoona beds Stuart Range Formation Boorthanna Formation
DEV	Unnamed
ORDOVICIAN	Blue Hills Sandstone Mintabie/ Cartu beds Indulkana Shale Mt. Chandler Sandstone Byilkaoora Formation
CAMBRIAN	Trainor Hill Sandstone Apamurra Formation Mt. Johns Conglomerate Arcoeillinna Sandstone Observatory Hill Formation Wallatinna Formation Ouldburra Formation Relief Sandstone (Marla Group)
NEOPROTEROZOIC	Upper — **Ungoolya Group** Lower — (Rodda beds) Murnaroo Formation Meramangye Formation Tarlina Sandstone
NEOPROTEROZOIC	Alinya Formation Pindyin Sandstone
Mesoproterozoic basement	

The erosion surface (sequence boundary) at the top of the Willouran marks a major turning point in the evolution of the Officer Basin. The surface extends from a depth of 600 ms (TWT) in the southeastern part of the study area over the Ammaroodinna Ridge to as deep as 3800 ms in the Munyarai Trough close to the northern margin of the basin. The structural ridges occur in association with major faults especially in the Marla Overthrust zone and along the Ammaroodinna Ridge (Plate 3). For the most part, these ridges are fault generated but they were also enhanced by the flow of evaporite units from the underlying Alinya Formation. Locally, in the Marla Overthrust Zone, the Willouran units are brought close to the surface by major thrust faults.

The erosion surface on top of the Alinya Formation represents a major disconformity throughout most of the Officer Basin. It is only in the northeastern corner of the Officer Basin that any units of presumed Torrensian and Sturtian age are to be found. Interbedded sandstones and siltstones and partly disrupted diapiric rocks intersected in the Marla Overthrust Zone may be Torrensian or perhaps equivalent to the Willouran Nilpinna Beds and/or War Loan Beds which outcrop in the Peake and Denison Inliers (Ambrose & others, 1981). These units may be equivalent to the Hussar-Kanpa-Steptoe succession in the western Officer Basin (Townson, 1985). Sturtian glaciogenic rocks, the Chambers Bluff Tillite, occur along the northern margin of the basin overlying a quartzite which may be the Pindyin Sandstone (Wilson, 1952; Krieg, 1972, 1973; Preiss, 1993). The Calthorinna Tillite and an unnamed sandstone equivalent occur in the Peake and Denison Inliers (Ambrose & others, 1981; Preiss, 1993) and similar units have been intersected by drillholes further east. These units probably correlate with the Lupton and Turkey Hill Beds which overlie Torrensian units in the western Officer Basin (Townson, 1985). Chert clasts contained in the Chambers Bluff Tillite may have been derived from the Wright Hill Beds (Major, 1973) or from eroded remnants of Torrensian rocks in the Peake and Denision Inliers.

The apparent absence of Torrensian and Sturtian age units over most of the eastern Officer Basin suggests that this erosion surface may represent a time period of close to 100 m.y. (Gravestock & Lindsay, in press). A similar regional erosion surface is found above the Bitter Springs Formation in the Amadeus Basin. The pattern of sedimentation and tectonism above the surface is very similar to that observed during Willouran and Sturtian time in the Officer Basin (Lindsay, 1987; Lindsay & Korsch, 1989, 1991) except that rocks of Sturtian age are more widespread in the Amadeus Basin. In the Amadeus Basin quartzite and chert clasts derived from the underlying Heavitree Quartzite and Bitter Springs Formation are found in the diamictites of the Sturtian Areyonga Formation. They also imply a long time interval between their deposition in Willouran time and their erosion by the Sturtian glaciation (Lindsay, 1989).

Thinning of the crust and regional subsidence during Willouran time followed by uplift and, finally, stabilisation over very large areas of the Australian craton in Sturtian time suggest tectonic controls of continental or larger significance were in effect. This suggestion is amplified by evidence of rifting during the Sturtian in the Adelaide Geosyncline, western New South Wales and the Georgina Basin. The 190 m-thick tholeiitic basalt suite, the Wantapella Volcanics, in fault-bounded blocks along the basin's northern margin, may relate to crustal thinning which opened up the major sub-basins along the northern margin of the basin in Marinoan time and led to a major period of sediment accumulation. The extrusion of the volcanics, perhaps in earliest Marinoan time, appears to have ended this period of basin evolution.

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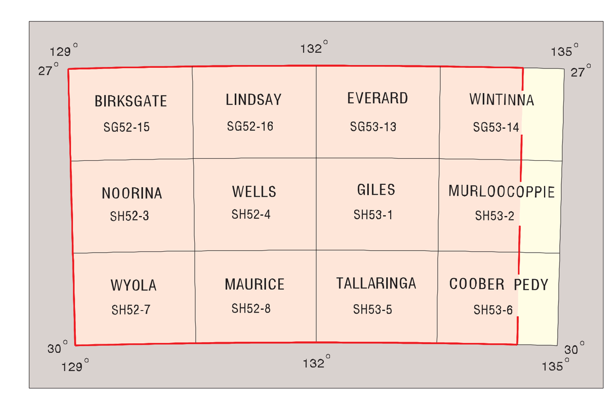
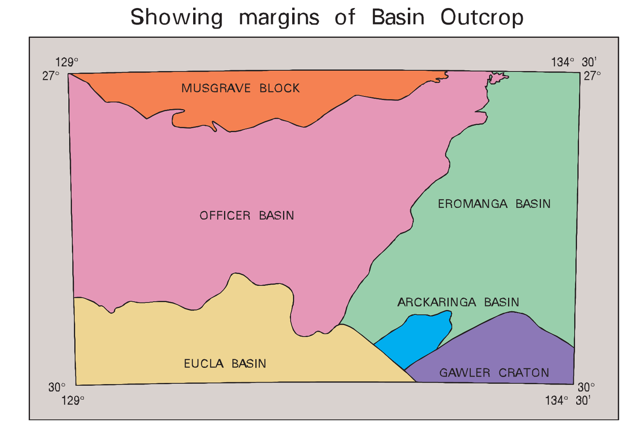


GEOLOGICAL PROVINCES

Showing margins of Basin Outcrop



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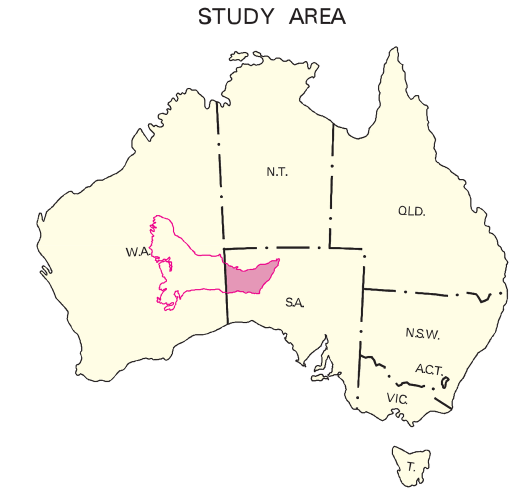

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GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 17

Depth to Top Willouran Sequence Boundary

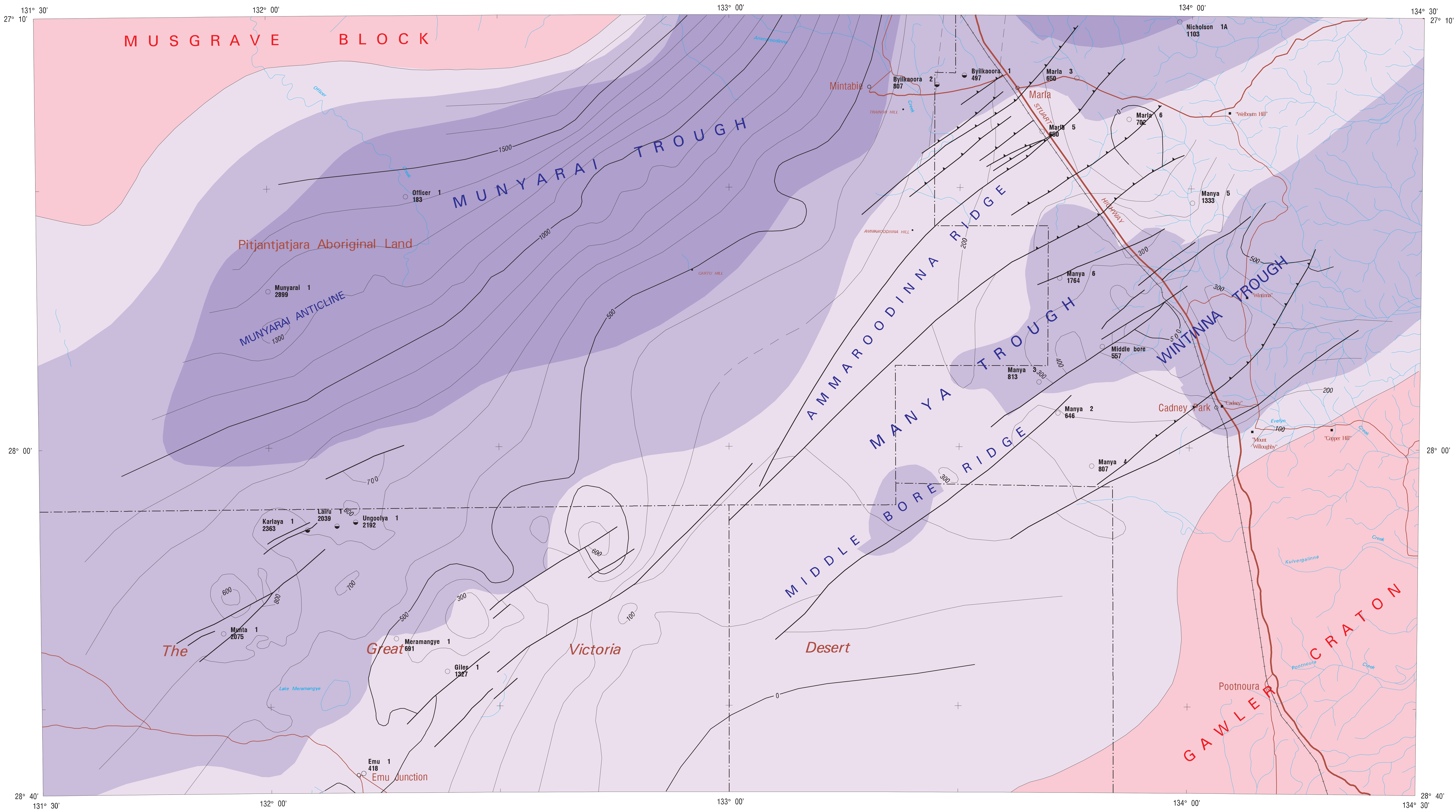
1995

OFFICER BASIN

SOUTH AUSTRALIA

Isochron of Late Neoproterozoic Succession

by J.F.Lindsay



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10 0 10 20 30 40 50 kilometres

Lambert Conformal Projection

Standard parallels 27°15'S 30°15'S

Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

—1000— Index contour with value (ms)

Officer 1 183 — Petroleum exploration well with name and depth

Petroleum exploration well with show of oil

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

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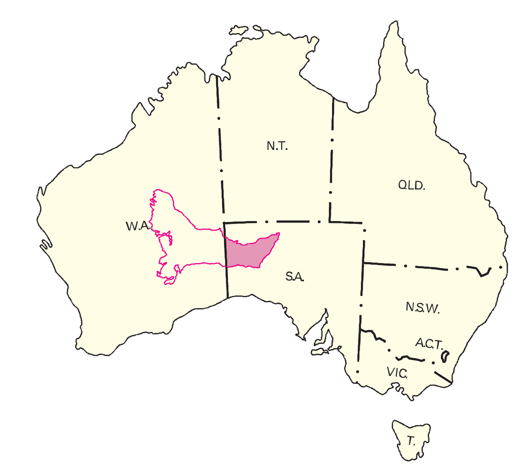
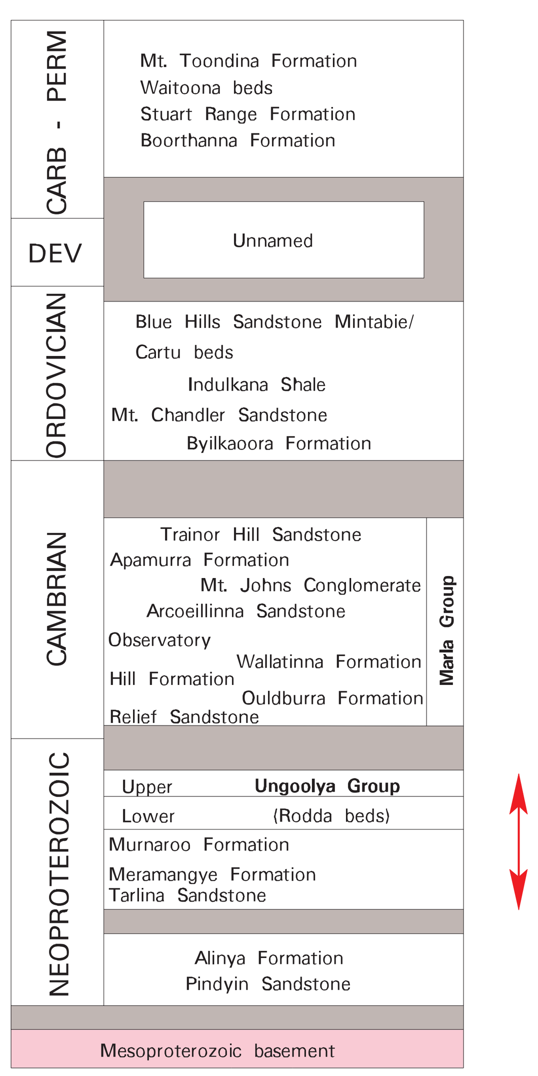
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

STUDY AREA





This plate shows the thickness of the Marinoan units of the eastern Officer Basin between the major sequence boundary overlying the Alinya Formation and the Precambrian-Cambrian boundary. Basin architecture changed dramatically with the beginning of Marinoan sedimentation. Where, during Willouran time, subsidence rates had been low and relatively uniform over very large areas, the Marinoan saw the opening of deep sub-basins for the first time. The eastern Officer Basin subsided at relatively higher rates during this time with an average of 61.6 m/m.y. in Munyarai #1 and 10.8 m/m.y. in Giles #1 (Moussavi-Harami, 1994). Subsidence rates were probably much higher again in the deep sub-basin to the north of Munyarai #1 well. The isochrons thus show a wedge of sediment that is almost 2 s (TWT) thick in the deep sub-basin but thins towards the Murnaroo Platform and Ammaroodinna Ridge to less than 200 ms. The sub-basins appear to have formed as a response to moderate crustal thinning and thermal recovery (Lindsay & Leven, in prep.). The Marinoan succession is thus extensive, but not as widespread as the underlying Willouran units (see Plate 16), and because of the greater subsidence rates and increased accommodation, it marks the beginning of a major marine incursion into the basin. Stacking patterns visible on seismic reflection data suggest that subsidence rates declined with time in response to thermal decay. The evolution of the Amadeus Basin follows a very similar pattern (Lindsay & Korsch, 1989,1991). The complexity of the structure contours along the Ammaroodinna Ridge and around Ungoolya #1 and associated wells suggests that the evaporites within the Alinya Formation flowed throughout Marinoan time much as is observed in the same time interval in the Amadeus Basin (Lindsay, 1987).

Towards the top of the Ungoolya Group stacking patterns again change abruptly indicating a sudden decrease in subsidence rates above a major erosional surface or canyon-cutting event. The event resulted from both sea-level fall and tectonic activity that produced canyons more than 600 m in depth which locally eroded to the Meramangye Formation (Giles Mudstone of Sukanta & others, 1991; Sukanta, 1993). Proterozoic sedimentation was halted by uplift associated with the Petermann Ranges Orogeny, which was foreshadowed by the canyon-cutting event (see Plate 23). Consequently, above the erosion surface in the late Ungoolya Group (see Plate 25), sequence boundaries are more closely spaced although there is little lithologic change.

Prospectivity

During Comalco's exploration in the Munta area their search for petroleum was centred on the Ungoolya Group siltstones which, it was hoped, had significant fracture porosity; this did not eventuate. Only two wells (Giles #1, Ungoolya #1) targeted anticlinal closures. Current interpretation suggests these wells were drilled off-structure (Gravestock, 1994).

Two units, the Dey-Dey Mudstone and Narana Formation at the base and top of the Neoproterozoic Ungoolya Group respectively have TOC values that range up to 1.47 % (87 samples, mean 0.28%). The richest samples are from transgressive and late highstand systems tracts but sampling has been random as shown by the low mean value. Highest values are from the Lake Maurice West drillhole. Extracts from oil bleeds indicate a marine source from sterane distributions; molecular assemblages are similar to those reported from Oman and Siberia. Recent studies in the Birksgate Sub-basin have shown that these potential source units are much thicker than had originally been anticipated (Lindsay & Leven, in prep.)

The alluvial-tidal-shallow marine Tarlina Sandstone disconformably overlies the Alinya Formation on the Murnaroo Platform and provides the best potential reservoir interval (porosity 9.0 - 19.6%, mean 15.9%; permeability 0.16 4.5 md, mean 1.2 md). It is arkosic with calculated Vshale of 5 to 25%. The Murnaroo Formation was deposited in similar environments and occurs on the Murnaroo Platform and east of the Manya Trough (porosity 1.2 - 18.8%, mean 14%; permeability 0.01213 md, mean 20 md). It is feldspathic, micaceous and locally glauconitic.

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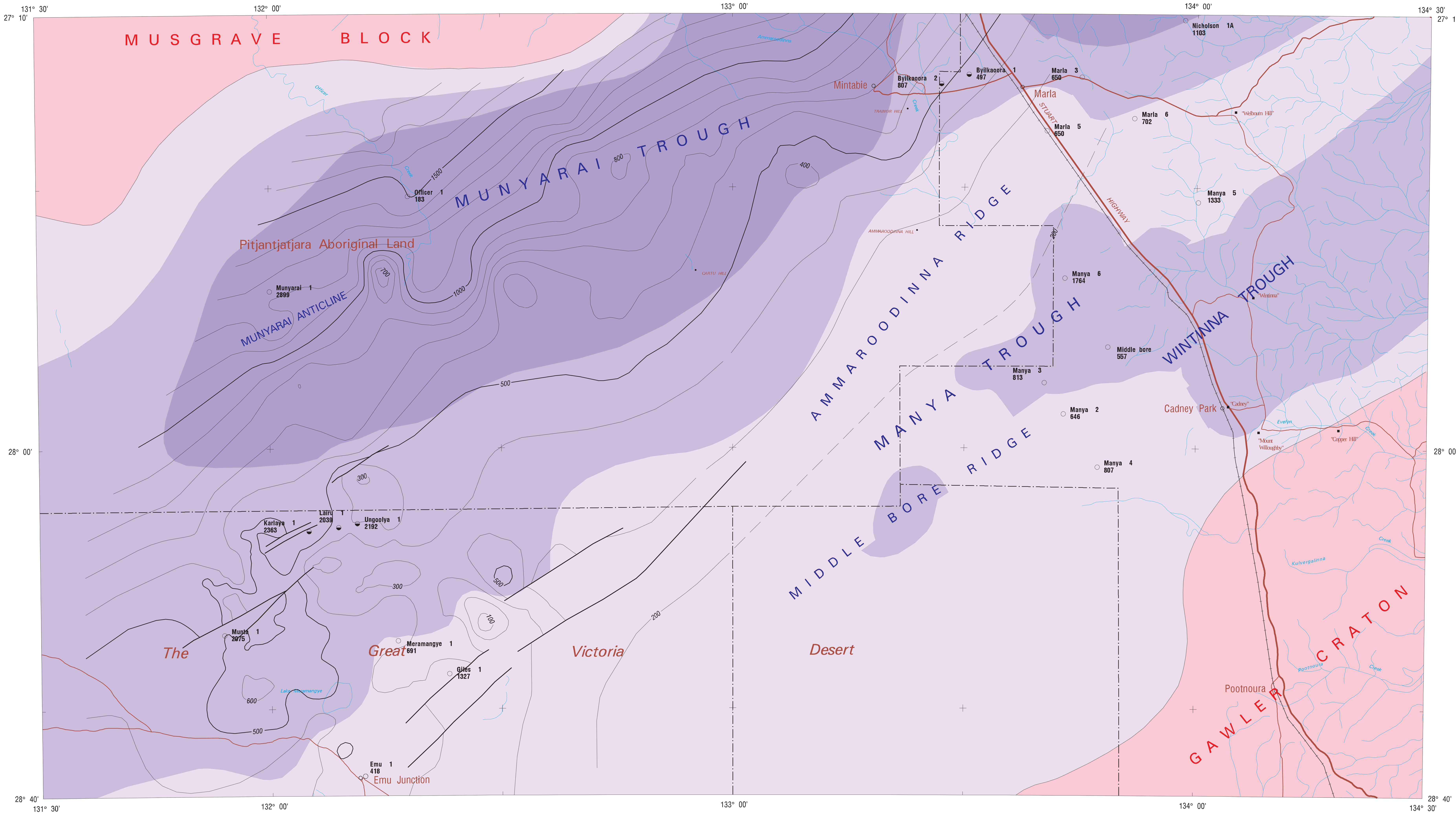
MINES AND ENERGY SOUTH AUSTRALIA

OFFICER BASIN

SOUTH AUSTRALIA

Isochron of Early Marinoan I Succession

by J.F.Lindsay



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Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

1000 — *Index contour with value (ms)*

Officer 1 183 — *Petroleum exploration well with name and depth*

Petroleum exploration well with show of oil

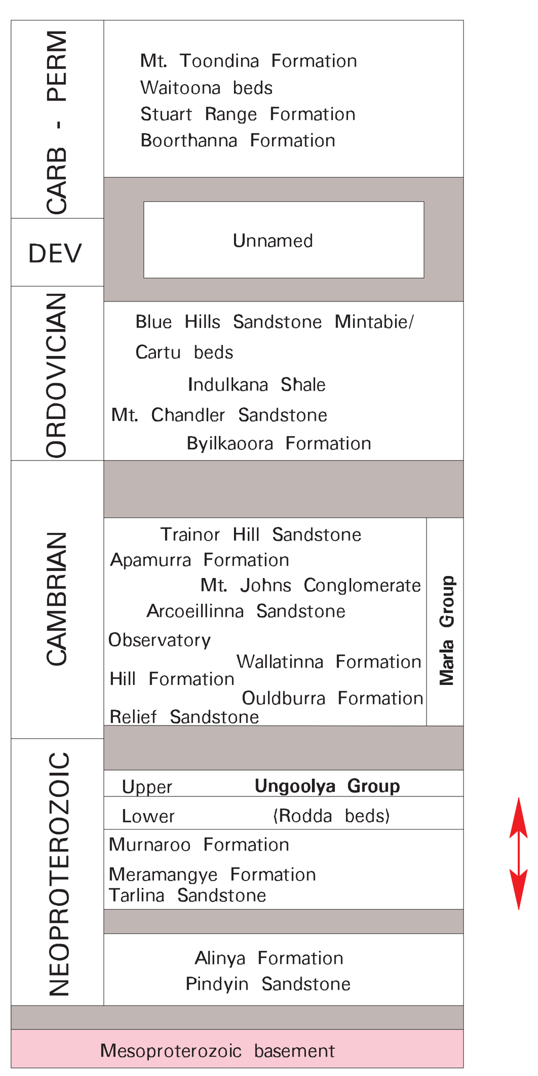
Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms



The early Marinoan rocks mapped here include units between the major sequence boundary (erosion surface) on the Alinya Formation (Plate 17) and the deeply eroded canyon surface above the Munyarai Mudstone (Plate 24). The isochrons are geometrically relatively simple suggesting that at this time a narrow sub-basin had formed along the northern margin of the basin allowing the accumulation of at least 2s (TWT) of sediment. The succession thins rapidly to the southeast towards the position of the Ammaroodinna Ridge suggesting that the ridge had begun to grow by this time. The localised complexity of the isochrons around Ungoolya #1 and Meramangye #1 wells indicates that these smaller structures had also begun to grow. In contrast, evidence of growth on the major structure beneath Munyarai #1 is minimal and it appears to lie north of the shelf edge in a basinal setting at this time.

The mapped interval consists of two major components; a lower package consisting of the Tarlina Sandstone, Meramangye and Murnaroo Formations and an upper package consisting of the lower Ungoolya Group (Dey Dey Mudstone, Karlaya Limestone, Tanana and Munyarai Formations). Seismically the lower package is relatively consistent in thickness (approximately 500 ms) over a large area. At the start of Marinoan time braided fluvial clastic sediments of the Tarlina Formation spread across the Murnaroo Platform to form a thick transgressive systems tract, resting upon a very sharply defined sequence boundary and indicating the start of a new phase of subsidence. Seismically, the unit is very continuous and can be seen to extend into the Munyarai Trough. The regional facies distribution of the unit is not well understood as it has only been intersected in a small number of drillholes. It reaches a thickness of 167m in Giles #1 and 150 m in Lake Maurice West #1 and Lake Maurice East #1 (Sukanta, 1993; Sukanta & others, in prep.).

The first major marine incursion into the Officer Basin is recorded by a 192m thick wedge of fine grained clastic rocks of the Meramangye Formation (Stainton & others, 1988; Sukanta, 1993) which intertongues with the Murnaroo Formation to the south and thickens into the Munyarai Trough to the north thus forming the first highstand systems tract in the new phase of subsidence. Locally, strong internal reflections can be seen within the Meramangye Formation with poorly defined prograding units in between them downlapping onto the stronger reflections suggesting that the formation consists of at least three, and possibly more, thin highstand systems tracts. The Meramangye Formation also occurs in the Marla Overthrust Zone (Gravestock & Lindsay, in press) and probably in exposures at Chambers Bluff (Preiss, 1993). The intertonguing to conformably overlying marine sandstone and siltstone of the Murnaroo Formation reaches 580m thickness in Lake Maurice East #1 and a thin remnant occurs in Marla #9 (Gatehouse & others, 1986; Brewer & others, 1987; Sukanta, 1993). A 600 m-thick cross-bedded sandstone at the eastern end of the basin is probably a fluvial to shallow marine equivalent of the Meramangye Formation.

In general, where observed in wells, the Murnaroo Formation appear to form a separate depositional sequence overlying the Meramangye Formation. Where intersected by drill holes towards the basin margin it shows evidence of being deposited in a tidal, shelfal and shoreface setting (Sukanta, 1993). Basinward the formation is almost certainly of somewhat deeper water basinal origin as its seismic signature is similar to that of the overlying Ungoolya Group. Seismic evidence of downlap on internal surfaces suggests that the Murnaroo Formation may in fact be at least two sequences. The distribution of the Meramangye and Murnaroo Formations further west in the Birksgate Sub-basin is not known but acritarch studies in Birksgate #1 well suggest they correlate with the lower Wright Hill Beds (Zang, 1993).

The lower Ungoolya Group or lower Rodda beds (Sukanta, 1993; Sukanta & others, in prep.; Krieg, 1972, 1973) consists of an alternation of mudstones and carbonates (Dey-Dey Mudstone, Karlaya Limestone, Tanana Formation, Munyarai Formation) ranging from deep marine transgressive to very shallow late highstand environments (Sukanta, 1993). At least three major depositional sequences can be identified with thin carbonate units forming a transgressive systems tract which is then overlain by a silty or muddy highstand systems tract. The most pronounced of these sequences is the Karlaya Limestone (Plate 21) and the overlying Tanana Formation (Plate 23). Basinward a prograding wedge, part of the Dey Dey Mudstone, has been identified as a lowstand systems tract (see Plate 22).

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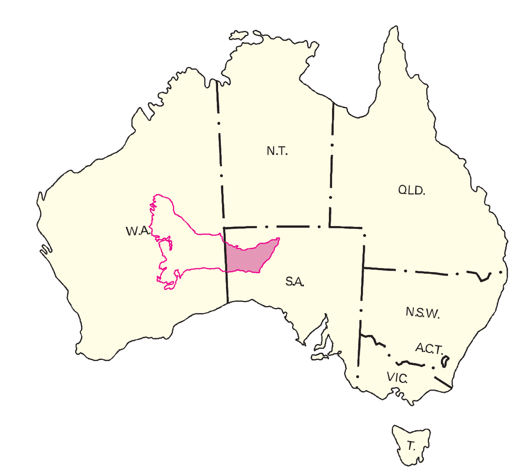

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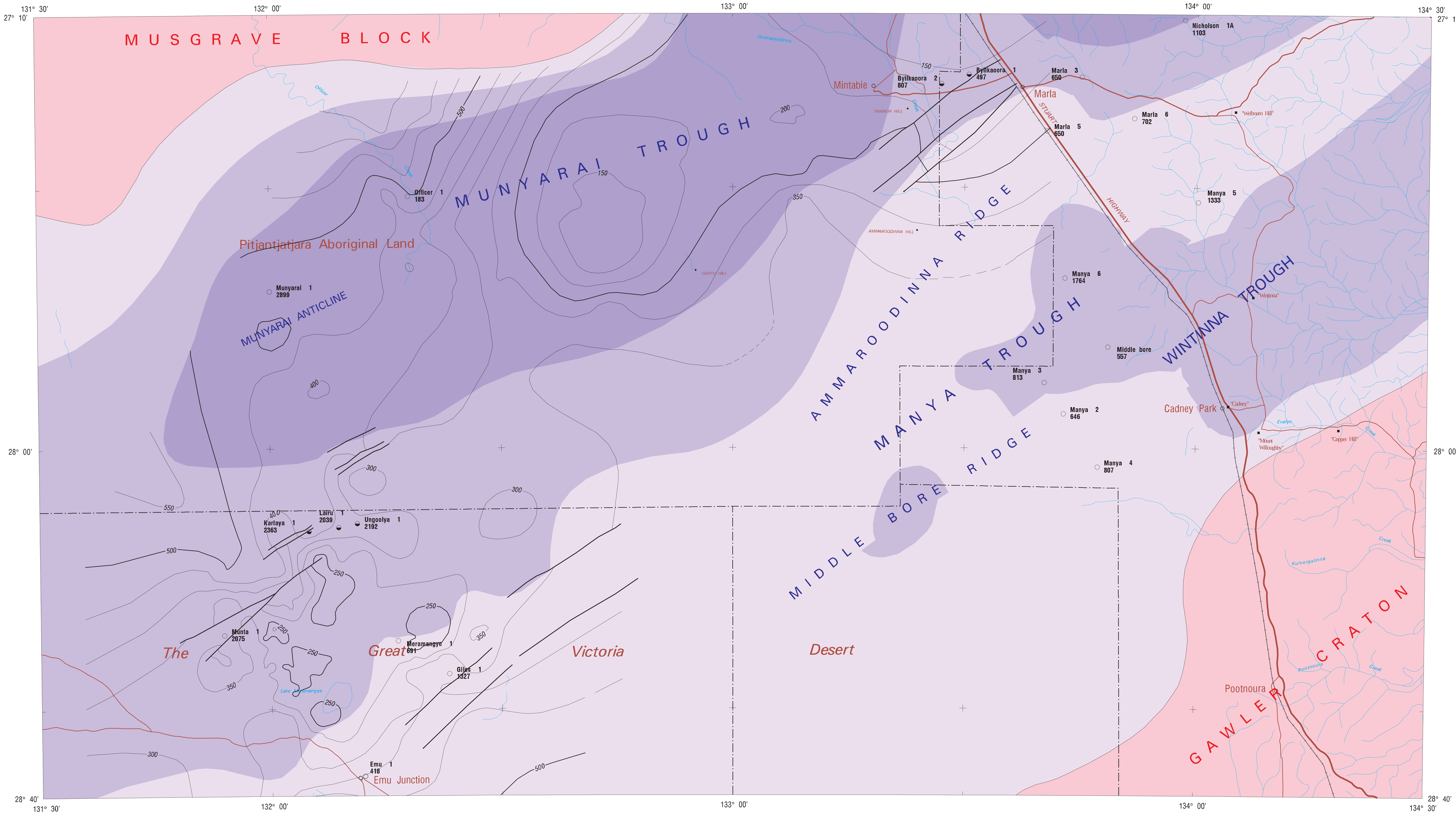
MINES AND ENERGY
SOUTH AUSTRALIA

OFFICER BASIN

SOUTH AUSTRALIA

Isochron of Early Marinoan II Succession

by J.F.Lindsay



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Standard parallels 27°15'S 30°15'S

Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

1000 Index contour with value (ms)

Officer 1 183 Petroleum exploration well with name and depth

Petroleum exploration well with show of oil

Crystalline basement

TWT basement

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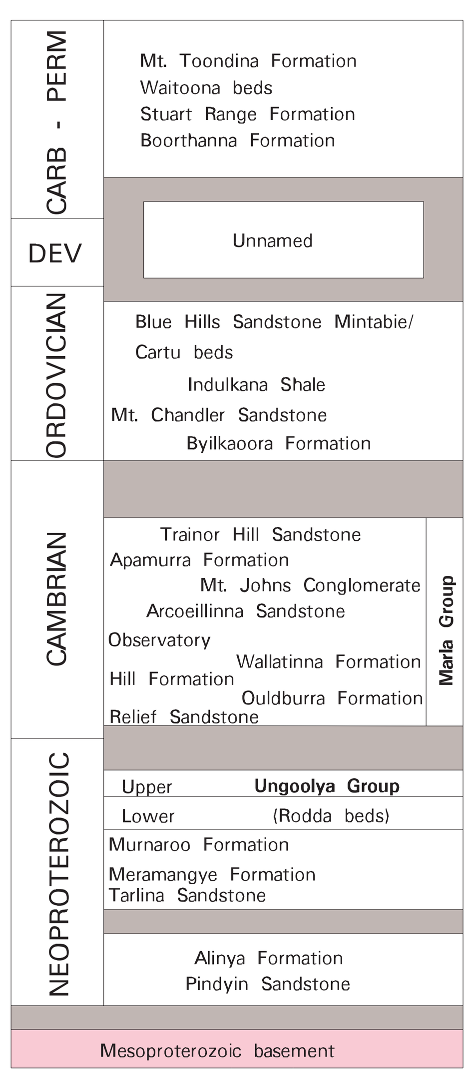

Isochrons of the earliest units of Marinoan age provide evidence of the early evolution of the eastern Officer Basin. The mapped interval, which includes lithologic units between the prominent erosion surface at the top of the Alinya Formation (Plate 17) and the sequence boundary at the base of the Karlaya Limestone (Plate 21), involves the Tarlina Sandstone, Meramangye Formation, Murnaroo Formation and the lowest unit of the Ungoolya Group the Dey Dey Mudstone (Sukanta, 1993; Gravestock & Lindsay, in press). The isochrons are relatively complex and show first, the early evolution of the Munyarai Trough which contained more than 500 ms (TWT) of sedimentary rocks. Second, the isochrons provide clear evidence of the early movement of halite within the Alinya Formation. Thickening of the sedimentary succession parallel to the Ammaroodinna Ridge suggests movement of salt to the southeast into the growing structure. Similarly, thinning of the succession in the area around Meramangye #1 well and associated thickening northwestward around Karlaya #1, Ungoolya #1 and Giles #1 wells all point to movement of halite into the structural high beneath Meramangye #1. Movement presumably occurred in response to sediment loading and the development of the sub-basin. The main variations in thickness of this unit are associated with the Dey Dey Mudstone, a prograding highstand unit overlying a prominent erosion surface (sequence boundary) on top of the Murnaroo Formation. The lower units form a package of relatively uniform thickness of approximately 500 ms (TWT) suggesting regional subsidence. Presumably the sub-basins began to evolve rapidly following deposition of the Murnaroo Formation.

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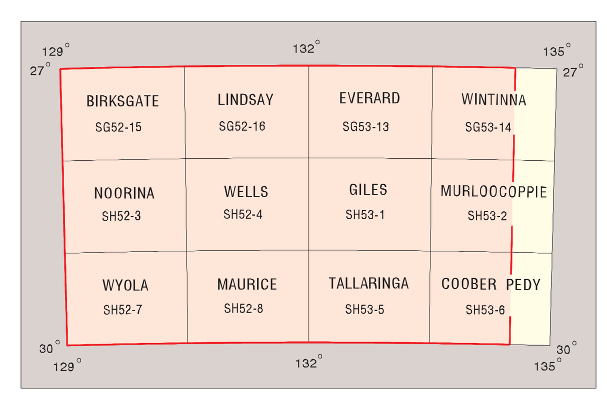

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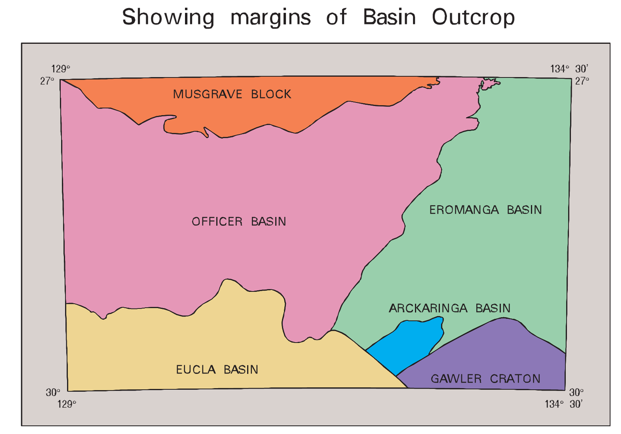
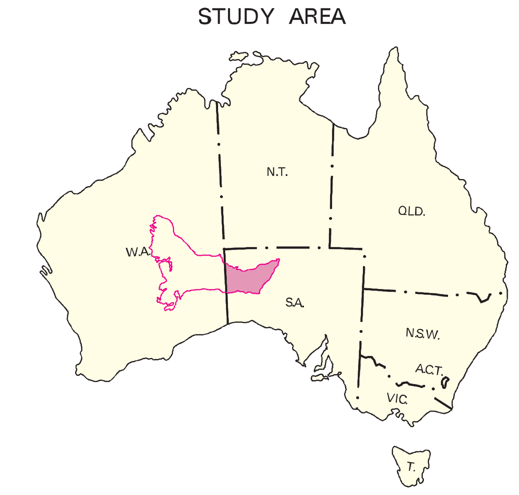
Showing margins of Basin Outcrop



STUDY AREA



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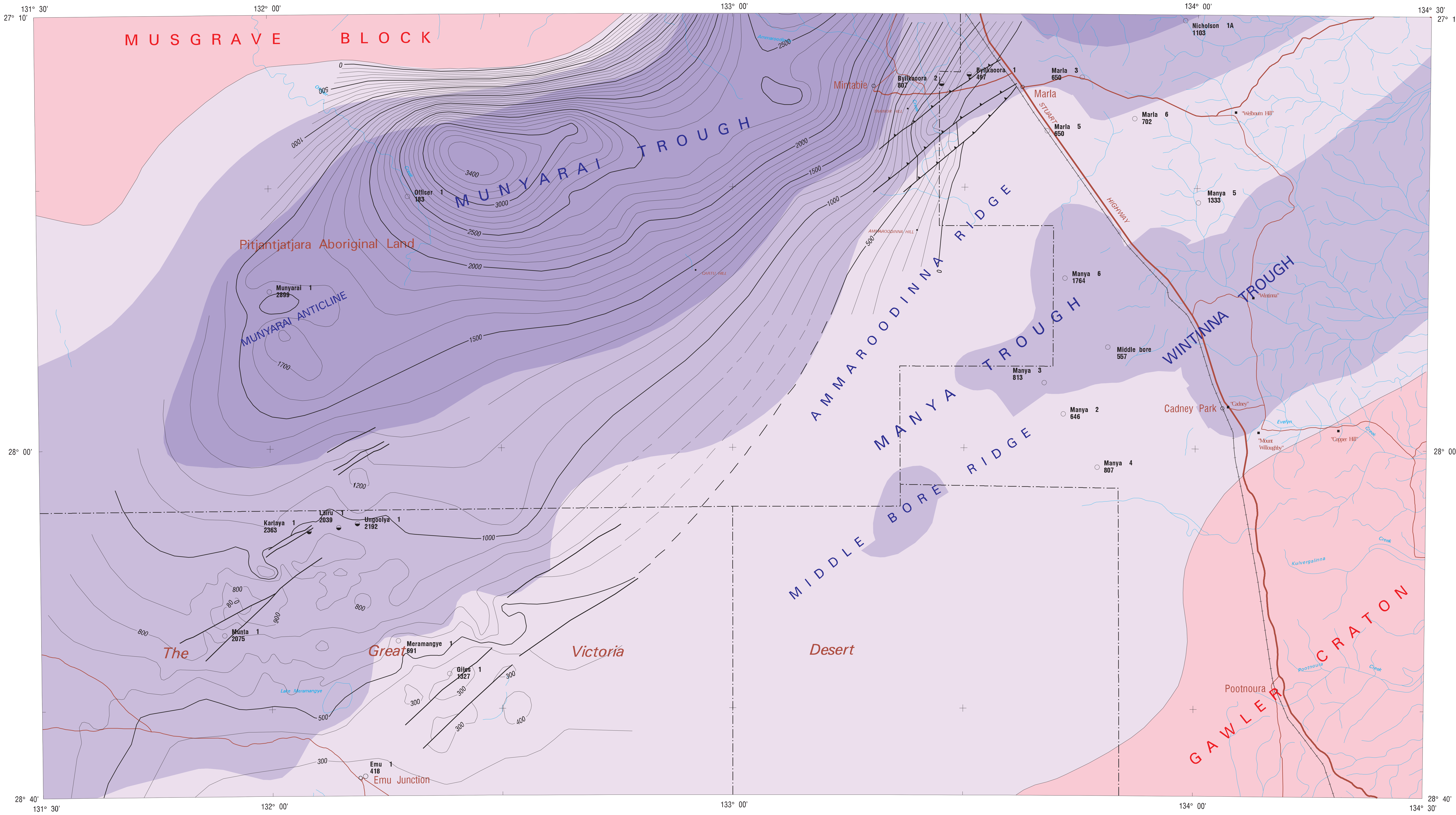
MINES AND ENERGY SOUTH AUSTRALIA



OFFICER BASIN

SOUTH AUSTRALIA

Depth to Karlaya Limestone (Marinoan)

by J.F.Lindsay

Scale 1:500 000

10 0 10 20 30 40 50 kilometres

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

1000 *Index contour with value (ms)*

Officer 1 183 *Petroleum exploration well with name and depth*

Petroleum exploration well with show of oil

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

Compiled 1990-1994 by J.F.Lindsay, AGSO
Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
Data processing by K.Reine, AGSO using Petrosys software
Cartography by A.J.Retter, AGSO
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Topographic detail based on information supplied by the Department of Environment and Natural Resources, South Australia.

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Published jointly by the Australian Geological Survey Organisation, Canberra, Australia and the Department of Mines and Energy, South Australia, Adelaide, as part of the National Geoscience Mapping Accord

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Depth to Karlaya Limestone (Marinoan) (1:500 000)
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

CARB - PERM	Mt. Toondina Formation Waitoona beds Stuart Range Formation Boorthanna Formation
DEV	Unnamed
ORDOVICIAN	Blue Hills Sandstone Mintabie/ Cartu beds Indulkana Shale Mt. Chandler Sandstone Byilkaoora Formation
CAMBRIAN	Trainor Hill Sandstone Apamurra Formation Mt. Johns Conglomerate Arcoeillinna Sandstone Observatory Hill Formation Wallatinna Formation Ouldburra Formation Relief Sandstone (**Marla Group**)
NEOPROTEROZOIC	Upper **Ungoolya Group** Lower (Rodda beds) Murnaroo Formation Meramangye Formation Tarlina Sandstone Alinya Formation Pindyin Sandstone
	Mesoproterozoic basement

A number of thin carbonate units occur in a distinctive but widely spaced stacking pattern throughout the Ungoolya Group alternating with poorly sorted silty or muddy clastic units (Sukanta & others, 1991; Sukanta, 1993). In outcrop these limestones appear as prominent strike ridges and provide evidence of slump deformation suggesting at least moderate palaeoslopes (Krieg, 1972, 1973; Preiss & Krieg, 1992). Because of the velocity contrast with interbedded clastic units these thin carbonate units are imaged as prominent compound reflections on most seismic profiles in the eastern Officer Basin. The Karlaya Limestone is relatively typical of these units and can be mapped seismically across large areas of the eastern Officer Basin and as far west as the Birksgate #1 well. The Karlaya Limestone onlaps the Ammaroodinna Ridge along the southern margin of the Munyarai Sub-basin at a depth of 400-500 ms (TWT) and reaches close to the surface at the eastern end of the basin in the vicinity of the complex faulting in the Marla Overthrust Zone. Basinward in the Munyarai Trough the unit reaches depths in excess of 3 s before turning upward into the Musgrave Homocline or Woodroffe Thrust along the basin's northern margin.

The Karlaya Limestone forms the transgressive systems tract of the lowermost of the two depositional sequences that form the bulk of the overlying Tanana and Munyarai Formations (see Plate 23). Except where removed by later erosion during the canyon-forming event (see Plate 24) the Karlaya Limestone is present in most drillholes in the Giles #1 and Murnaroo Platform areas (Sukanta, 1993; Gravestock & Lindsay, in press). It varies from tens of metres to more than 100 m in thickness. The lower contact of the unit is sharply defined. The carbonates consist of very fine-grained dark green to greyish green micrite intercalated with green marl; occasionally the limestone is nodular and stylolitic (Sukanta, 1993). In general, the carbonate units decrease in thickness upwards and are replaced by mudstone units which gradually increase in thickness. The transition from the carbonates to the fine grained clastics of the highstands is gradational. The transition occurs as a series of backstepping parasequences over an interval of as much as 80 to 100 m. Each parasequences consists of a coarsening upward cycle ending in siltstone or locally over structural highs as sandstone (e.g. at Karlaya #1 well). Some carbonate units have tepee-like structures preserved in red mudstone-rich intervals near the top of the cycles (Sukanta, 1993). These units occur on the structural highs suggesting shallow water and subaerial conditions.

The Karlaya Limestone is thus a regressive micritic limestone that was deposited under low energy conditions to form the transgressive systems tract of a major depositional sequence resulting from sealevel rise. The unit occupied broad and almost horizontal depositional surfaces of a subtidal to shelf (ramp) system and deepened upsection and basinward into an outer ramp (shelf) environment and ultimately a basinal environment in the Munyarai Trough.

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Krieg, G.W., 1973, EVERARD, South Australia, sheet SG53-13. South Australian Geological Survey. 1:250,000 series - Explanatory Notes.

Preiss, W.V., & Krieg, G.W., 1992, Stratigraphic drilling the northeastern Officer Basin: Rodda 2 well. *Mines and Energy Review, South Australia*, v. 158, p. 48-51.

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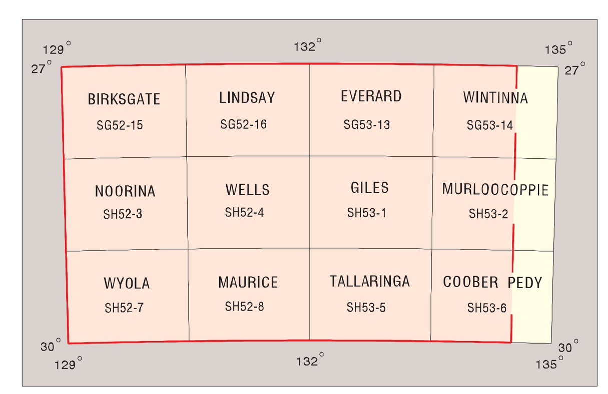
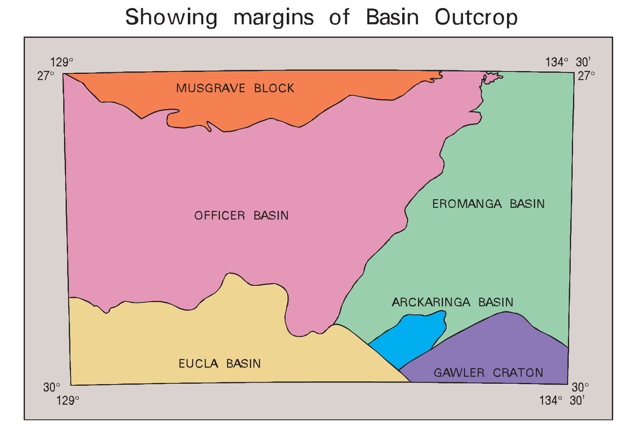
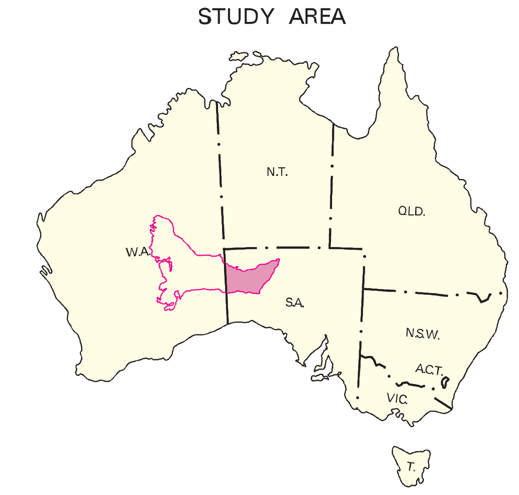


GEOLOGICAL PROVINCES

Showing margins of Basin Outcrop



STUDY AREA



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MINES AND ENERGY SOUTH AUSTRALIA

OFFICER BASIN

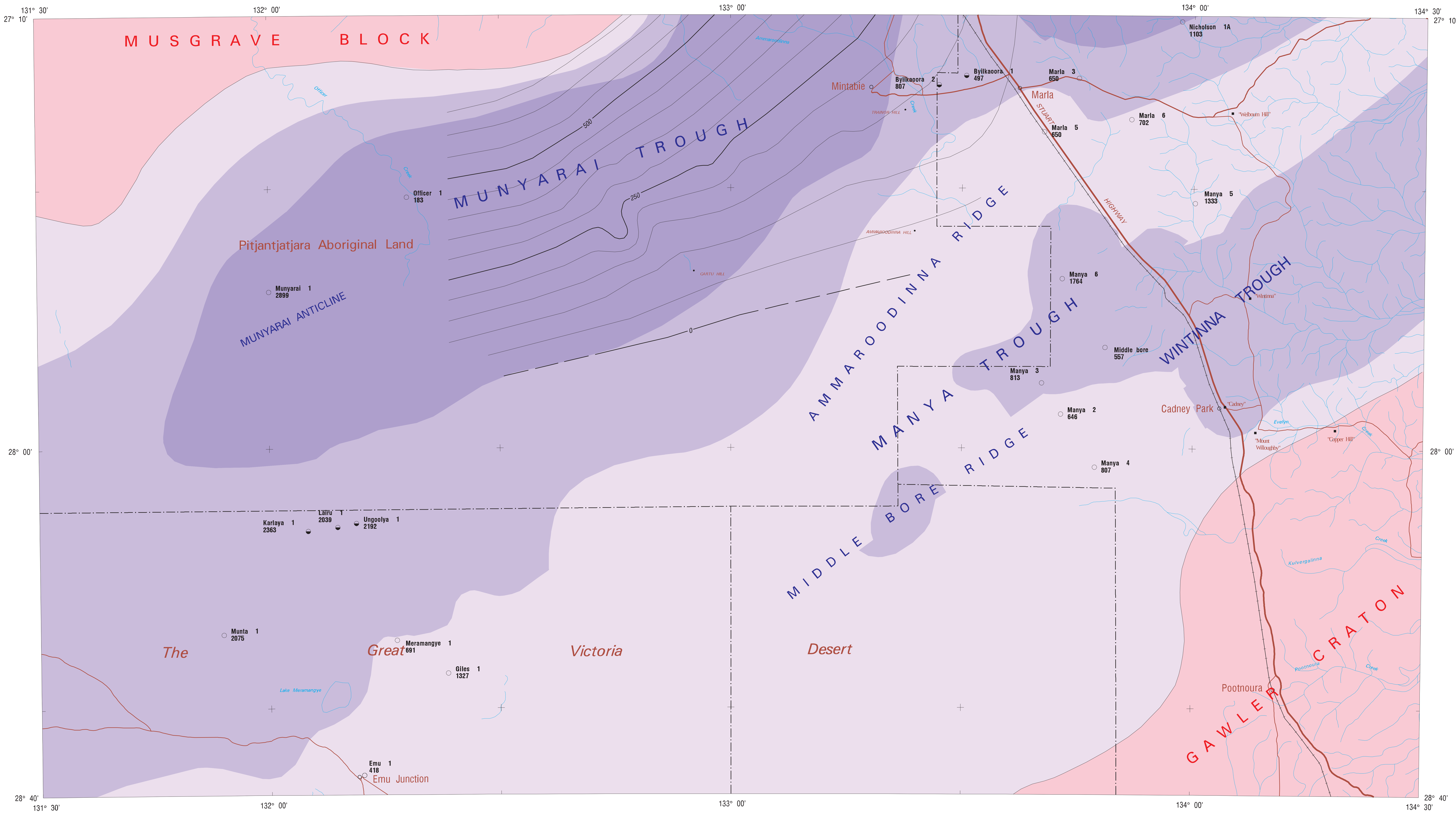
SOUTH AUSTRALIA

Isochron of Karlaya Limestone Lowstand Systems Tract (Marinoan)

by J.F.Lindsay

Scale 1:500 000

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E



Fault

Thrust fault. Triangle on older rocks

Contour

Index contour with value (ms)

Petroleum exploration well with name and depth

Petroleum exploration well with show of oil

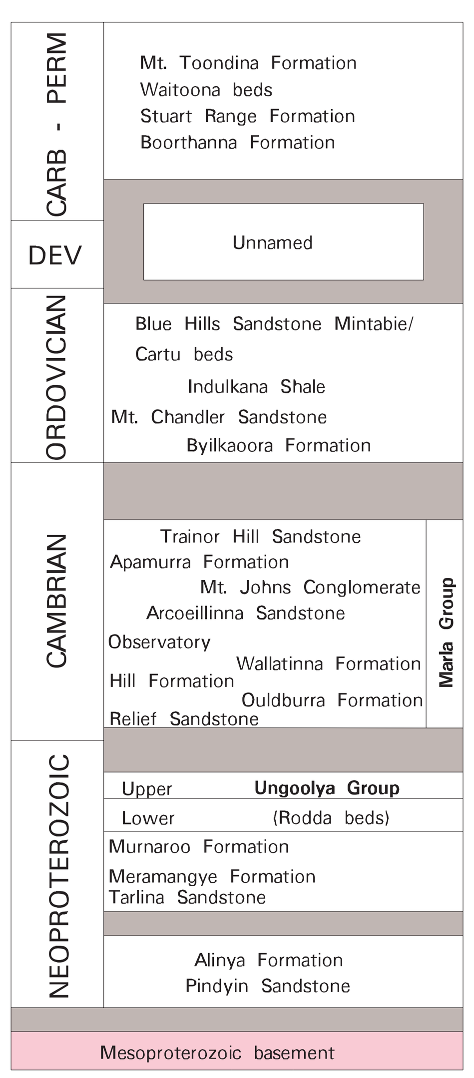
Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms



The lowstand systems tract associated with the Karlaya Limestone transgressive systems tract and the Tanana Formation highstand systems tract forms a wedge basinward of the Ammaroodinna Ridge and the Murnaroo Platform. The unit onlaps the Ammaroodinna Ridge at a depth of approximately 1600 ms (TWT). Basinward it is seen to reach a maximum thickness of approximately 700 ms although much of the unit was probably removed by erosion following the Alice Springs Orogeny. Because of its depth the lowstand has not been penetrated by drilling so its lithologic composition is not known. However, the seismic character of the unit is similar to the associated highstand systems tract, the Tanana Formation (lower Leemurra Mudstone of Sukanta, 1993), suggesting that it probably consists of silty, somewhat calcareous, mudstones and minor fine grained sandstones. In the present basinal lithostratigraphy the unit is included as part of the Dey Dey Mudstone rather than with the overlying Karlaya Limestone (Gravestock & Lindsay, in press). One of the two limestones that are exposed as prominent strike ridges at the type section of the Rodda beds (Krieg, 1972, 1973) may be equivalent to the Karlaya Limestone. However, there is no biostratigraphic control and no seismic tie to this locality northwest of the Marla Overthrust Zone. Deformed, folded and dismembered carbonate lenses within these units (Preiss & Krieg, 1992) suggest that the limestone may be part of the younger canyon fill.

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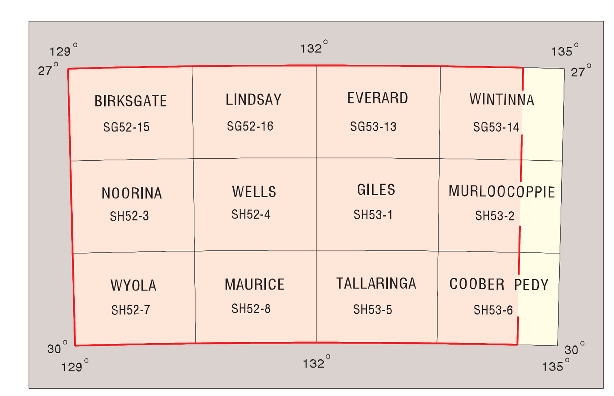
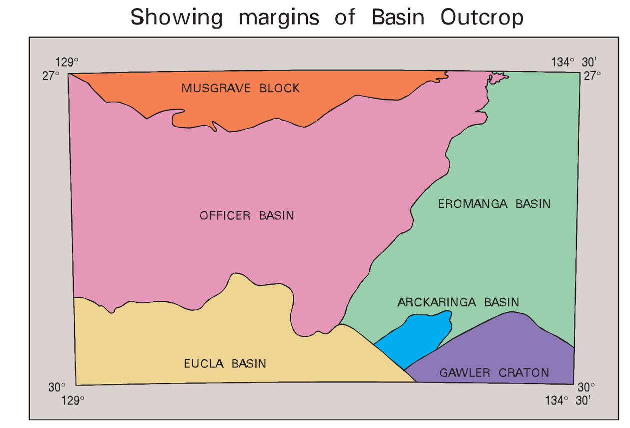


GEOLOGICAL PROVINCES

Showing margins of Basin Outcrop



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Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
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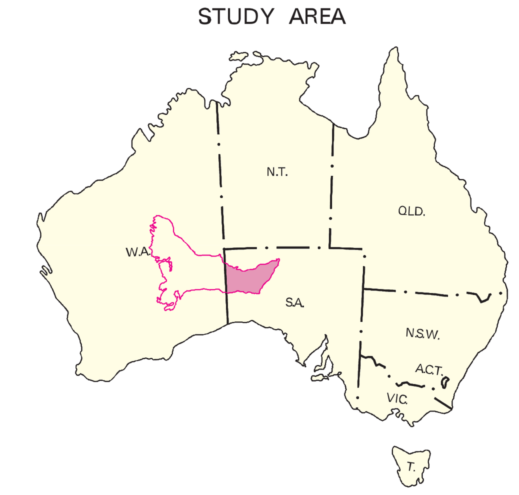
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

STUDY AREA



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MINES AND ENERGY SOUTH AUSTRALIA

AUSTRALIA

OFFICER BASIN

SOUTH AUSTRALIA

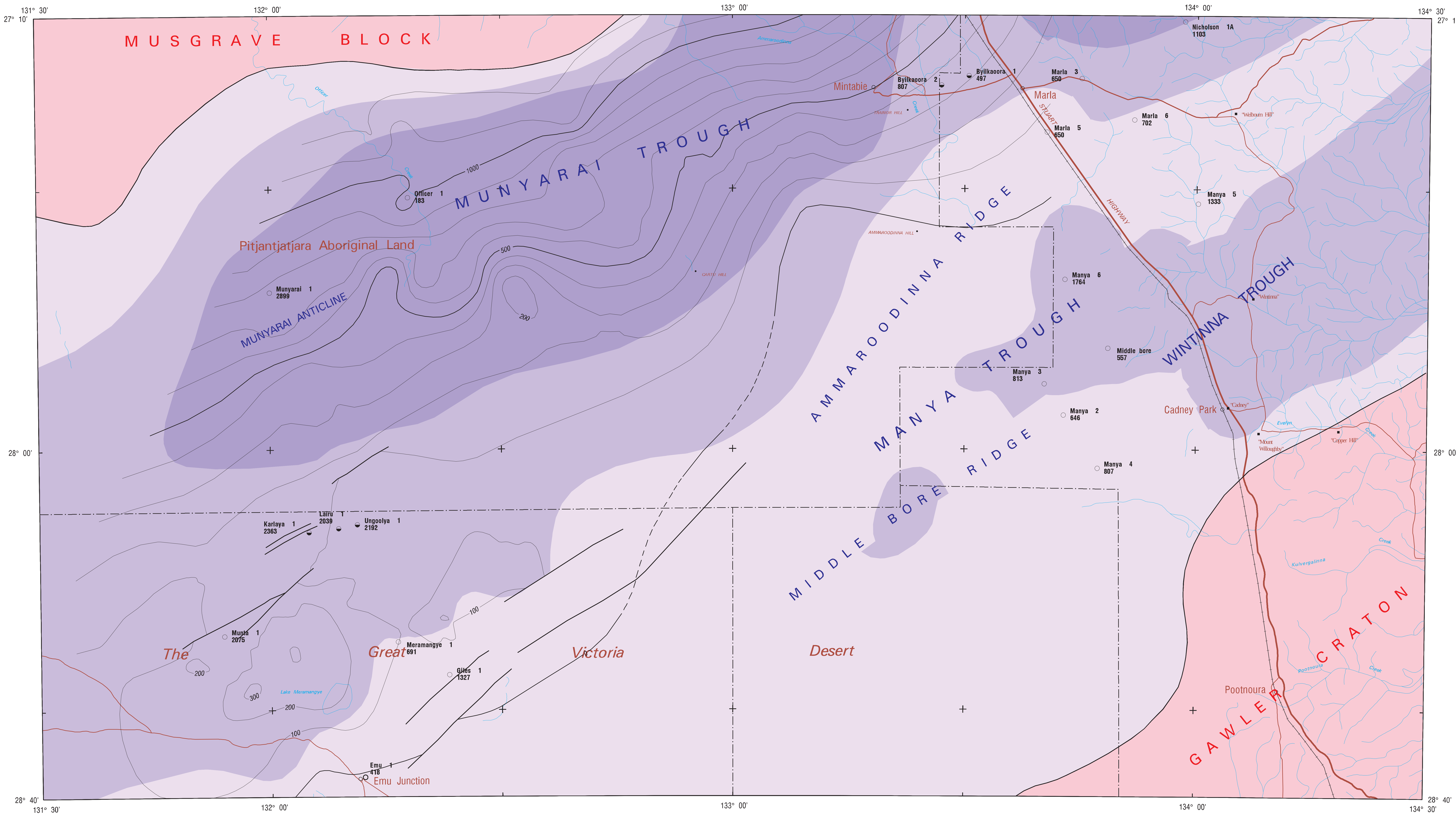
Isochron of Upper Part of Lower Ungoolya Group (Marinoan)

by J.F.Lindsay

Scale 1:500 000

10 0 10 20 30 40 50 kilometres

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E



Fault

Thrust fault. Triangle on older rocks

Contour

1000 Index contour with value (ms)

Officer 1 183 Petroleum exploration well with name and depth

Petroleum exploration well with show of oil

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

Compiled 1990-1994 by J.F.Lindsay, AGSO
Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
Data processing by K.Reine, AGSO using Petrosys software
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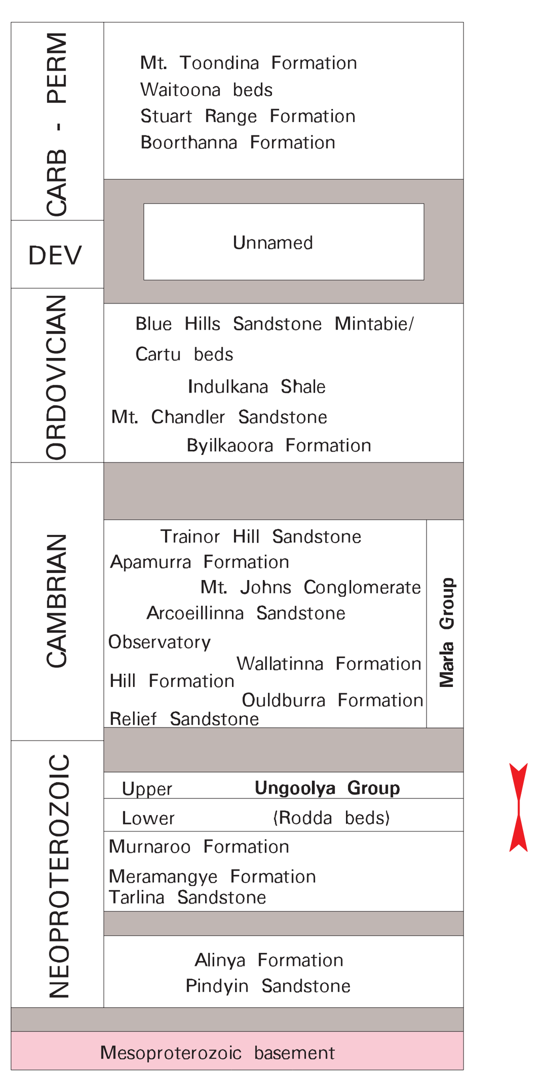
Isochron of Upper Part of Lower Ungoolya Group (1:500 000)
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia



The two depositional sequences consisting of the Karlaya, Tanana and Munyarai Formations form a well defined readily mappable lithostratigraphic unit at the top of the lower Ungoolya Group. The mapped unit is limited at its base by the distinctive fine grained carbonates of the Karlaya Limestone (Plate 21) and at its top by the prominent sequence boundary/erosion surface of the canyon forming event (Plate 24) (Sukanta, 1993). The two sequences mapped are relatively thin to the south and southwest of the map area where they onlap the Ammaroodinna Ridge and to the south of the highs around Munta #1, Ungoolya #1 and Giles #1 wells. They thicken rapidly toward the basin's northern margin. The Munyarai Trough was at this time clearly defined and it is apparent that the Ammaroodinna Ridge and the high to the southwest were well developed. The Munyarai Anticline had not, however, begun to evolve so that the Munyarai #1 well site lay within the sub-basin to the north of the slope break at that time. Because of the deeply eroded nature of the upper canyon-forming surface the isochrons of this interval, especially in the areas around the highs, are complex. For example, in the area around 132^{o} 30"E, 27^{o} 45"S the isochrons deviate basinward more than 20 km in response to a major canyon which cuts through the upper part of the formation on its passage to the deep sub-basin.

The mapped interval is dominated by mudstone but in reality is a complex interval formed of two separate depositional sequences each consisting of a thin fine-grained carbonate unit at its base (transgressive systems tract) overlain by a much thicker fine-grained clastic unit (highstand systems tract). The Karlaya Limestone forms the transgressive systems tract of the lower most of the two sequences. In each case the lower contact of the carbonate unit is sharply defined. The two carbonates are similar in composition and consist of very fine grained dark green to greyish green micrite intercalated with green marl; occasionally the limestone is nodular and stylolitic (Sukanta, 1993). The transition from the carbonates to the fine grained clastics of the highstands is gradational and occurs as a series of backstepping parasequences over an interval of as much as 80 to 100 m. Each parasequences consists of a coarsening upward cycle ending in siltstone or locally over structural highs as sandstone (e.g. at Karlaya #1 well). Some carbonate units have teepee-like structures preserved in red mudstone-rich intervals near the top of the cycles (Sukanta, 1993). Again these units occur on the structural highs suggesting shallow water and subaerial conditions.
The highstands consist for the most part of massive to laminated green mudstone. In most cases the silt and sand content of the highstands increases upwards. Generally, laminated mudstone and low-angle small-scale, cross-stratified muddy sandstone and normal grading parallel laminated siltstone-rich facies are associated with wavy, undulatory and silt-streaked laminae, and low-angle laminated truncations with channel-fill or small-scale onlap structures. Rarely laminated and low angle truncated sandstone beds that resemble hummocky cross-stratification are encountered. Soft-sediment deformation in the form of slumps occurs in the parallel-laminated sandy mudstone (Sukanta, 1993). Over structural highs and in the more proximal settings the highstands exhibit greater variation in lithology and have a much higher sand/silt ratio resulting in a much more complex gamma-ray log signature due to alternations in coarser and finer units. Basinward in Munyarai #1 the highstands are much finer grained and have a lower sand/silt ratio as might be expected in the more distal setting. Consequently, the gamma-ray log signature is much smoother. In spite of the fine-grained nature of the highstand the broad patterns of the parasequence cycles are still evident in the gamma-ray logs, especially the backstepping parasequences immediately above the carbonates of the transgressive systems tracts. The Birksgate #1 well was drilled at the centre of the Birksgate sub-basin and provides the only data on the upper part of the Marinoan in the basinal setting. Here the lateral equivalent of the mapped interval is more clastic rich and contains many normally-graded, medium to fine-grained sandstone units.

The mapped interval thus consists of at least two major depositional sequences each of which can be seen seismically to prograde basinward away from the major structural highs towards the southern margin of the Munyarai Trough. Regionally the setting can perhaps be visualised as a coastal plain to tidal setting on the structural highs to tidally dominated deltaic settings along the basin margin and ultimately a deeper-water turbidite dominated prodelta setting in the deeper sub-basins.

References

Sukanta, U., 1993, Sedimentology, sequence stratigraphy and palaeogeography of Marinoan sediments in the eastern Officer Basin, South Australia. Flinders University of South Australia, Ph.D. Thesis (unpublished).

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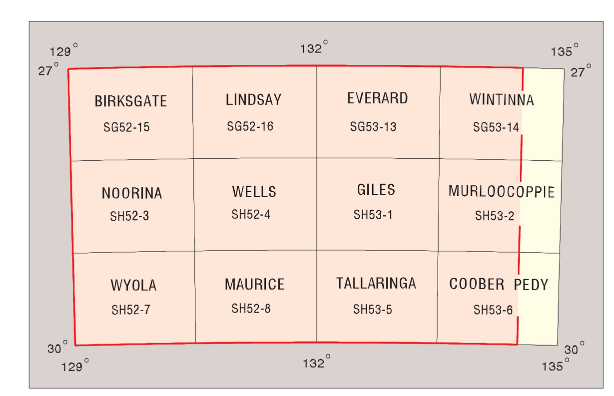
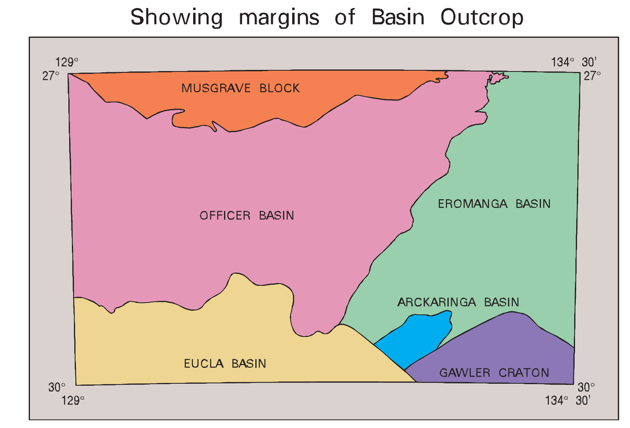


GEOLOGICAL PROVINCES

Showing margins of Basin Outcrop



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AGSO AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

MINES AND ENERGY SOUTH AUSTRALIA

OFFICER BASIN

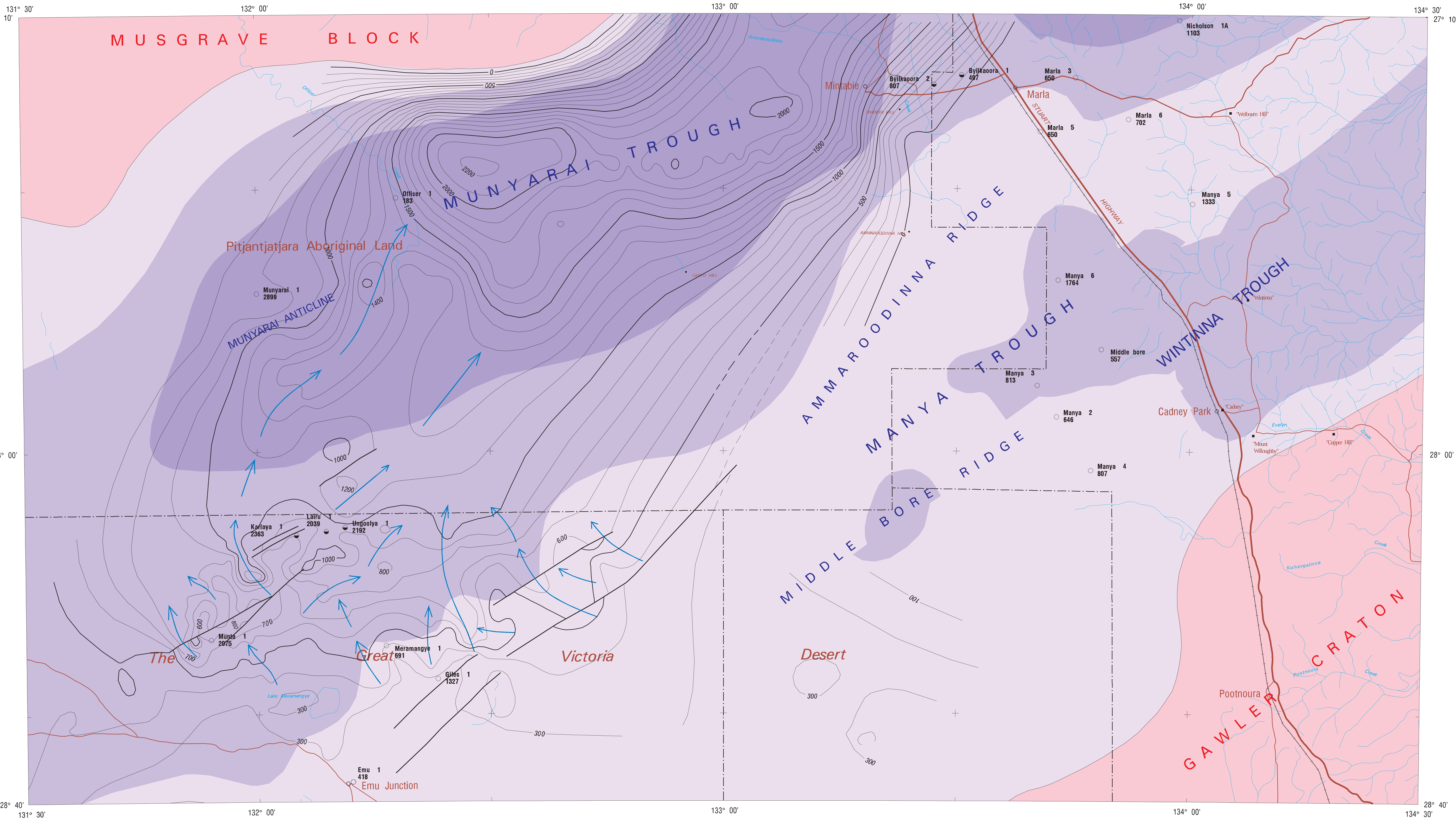
SOUTH AUSTRALIA

Depth to Marinoan Canyon Surface

by J.F.Lindsay

Scale 1:500 000

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E



Fault

Thrust fault. Triangle on older rocks

Contour

Index contour with value (ms)

Petroleum exploration well with name and depth

Petroleum exploration well with show of oil

Flow arrow

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

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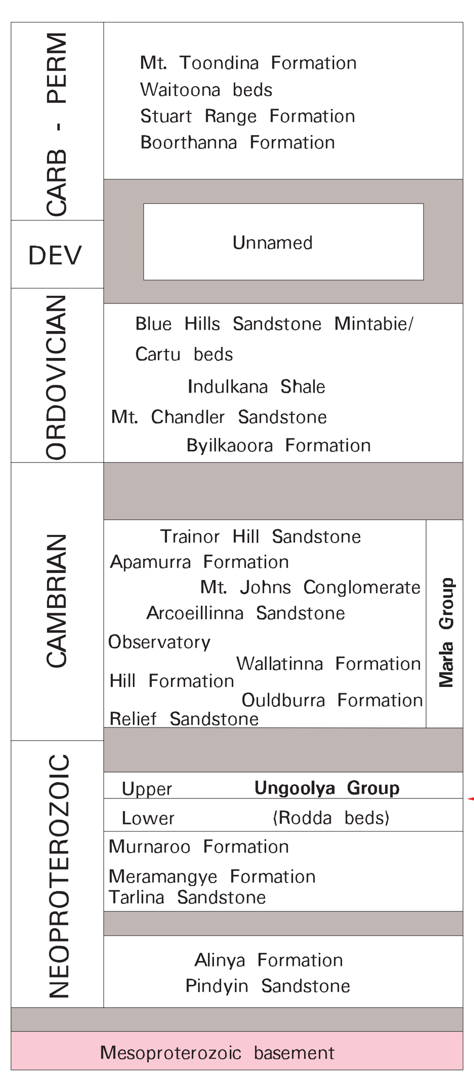

Perhaps the most striking sequence boundary within the Officer Basin succession is the surface characterised by a series of deeply incised valleys or canyons that breaks the Ungoolya Group into two parts (Upper and Lower) (Thomas, 1990; Sukanta & others, 1991). The canyons all originate around the highs associated with Munta #1, Giles #1 and Ungoolya #1 wells and the Ammaroodinna Ridge. At least five canyons run northwest and northward from this area into the Munyarai Trough. Most begin at depths of 500 to 600 ms (TWT) and appear to end at depths of around 1.8 s in the trough. The largest and most westerly of the canyons starts near Munta #1 well and is deflected eastward around the Munyarai High into the Munyarai Trough. The Munyarai Anticline was growing rapidly at that time. At least two smaller canyons run westward from the Munta structure heading into the Birksgate Sub-basin. The seismic grid does not extend far enough west to follow their full course but limited data suggest that the structure extends at least 60 km further to the west (see Plate 11, line 93AGS.L1). Both the Ammaroodinna Ridge and the Munyarai Anticline grew significantly during deposition of the overlying upper Ungoolya Group and it appears that the canyons are the result of this growth (see Plate 25). The growth was in large part tectonically induced but was amplified by the movement of salt from the underlying Alinya Beds into the structures. Early deep-seated faults within the Mesoproterozoic basement appear to have been reactivated by the Petermann Ranges Orogeny. However, the faults do not disrupt the basin fill but simply form a monocline in the Munyarai area with the resultant strain being taken up by the lateral movement of approximately 150 ms (c. 360 m) of Alinya Formation evaporites into the high.

The erosion surface within the Ungoolya Group shares many features in common with a surface of similar age in the Wonoka Formation in the Adelaide Geosyncline. These valleys were initially interpreted by Thomson (1969), von der Borch & others (1982, 1985) and Haines (1988, 1990) as submarine canyons, cut and filled in a relatively deep-marine setting, analogous to the Neogene canyons of modern continental margins. Eickhoff & others (1988), von der Borch & others (1989) and Christie-Blick & others (1990) describe features of the sedimentary fill that cast doubt on this interpretation, specifically the presence of sedimentary structures such as oscillation ripples and hummocky cross-stratification that have been taken to imply sedimentation above storm wave base. The evidence in the eastern Officer Basin appears to favour the first alternative as the canyons only appear over areas of active salt/tectonic growth. It thus appears likely that they were initiated by slope failure during tectonic activity and then became conduits for sediment movement much as proposed for similar canyons in the Gulf of Mexico (Coleman & others, 1983). An association between canyon cutting activity and diapiric growth has also been suggested for the Flinders Ranges canyons (Lemon, 1985; von der Borch & others, 1989)

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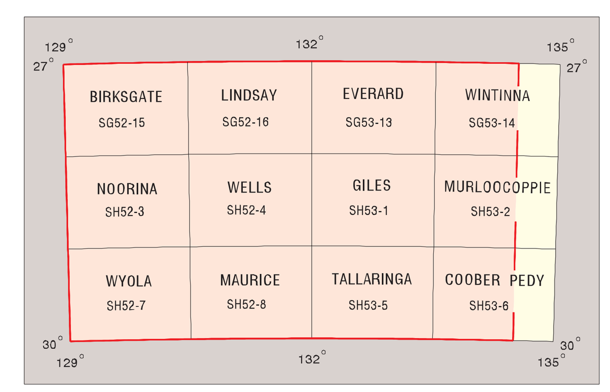
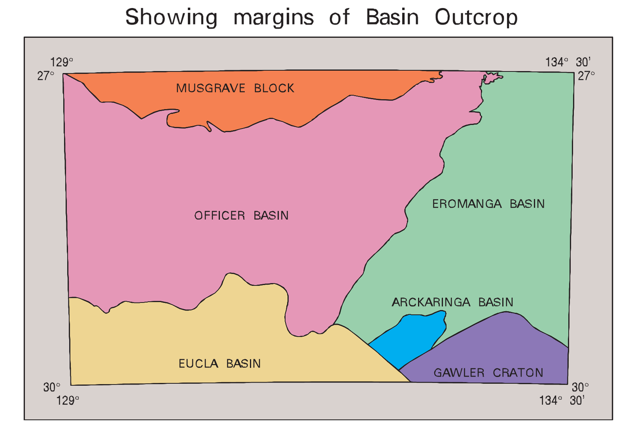
INDEX TO 1:250 000 MAPS



GEOLOGICAL PROVINCES

Showing margins of Basin Outcrop



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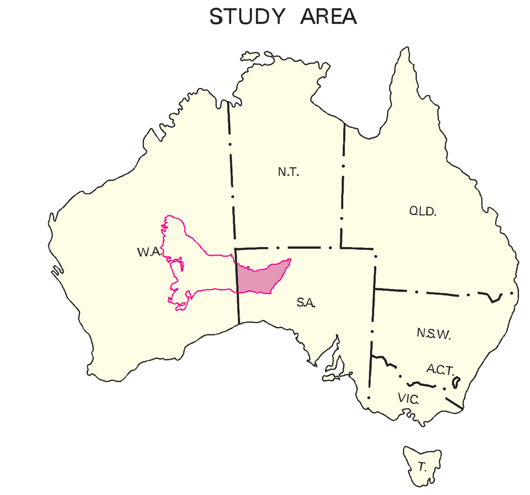

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MINES AND ENERGY
SOUTH AUSTRALIA

PLATE 24
Depth to Marinoan Canyon Surface
1995

OFFICER BASIN

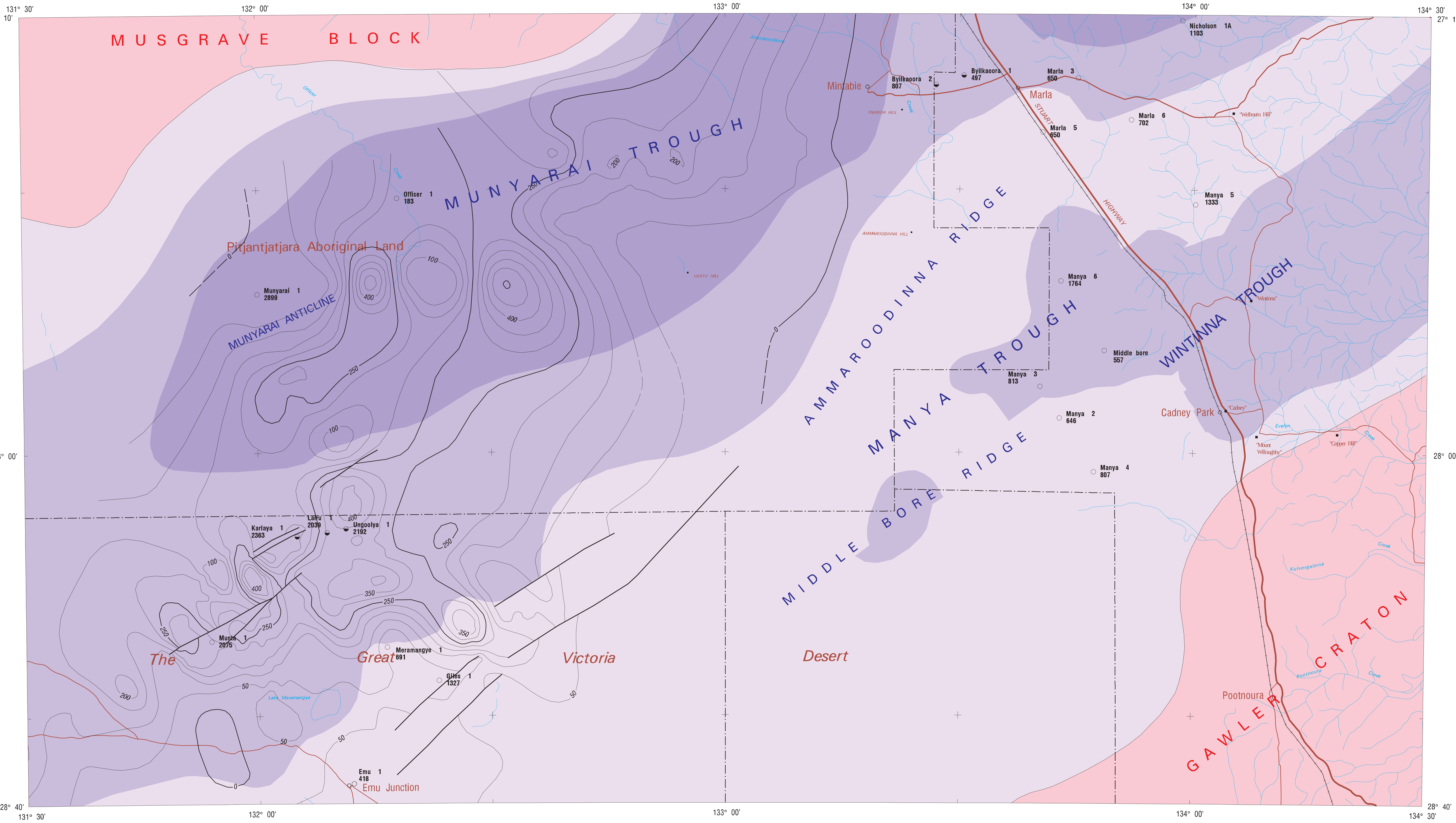
SOUTH AUSTRALIA

Isochron of Upper Ungoolya Group (Marinoan)

by J.F.Lindsay

Scale 1:500 000

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E



Fault
Thrust fault. Triangle on older rocks
Contour
Index contour with value (ms)
Petroleum exploration well with name and depth
Petroleum exploration well with show of oil
Crystalline basement
TWT basement
0 - 1000ms
1000 - 2000ms
> 2000ms

Compiled 1990-1994 by J.F.Lindsay, AGSO
Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
Data processing by K.Reine, AGSO using Petrosys software
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Topographic detail based on information supplied by the Department of Environment and Natural Resources, South Australia.

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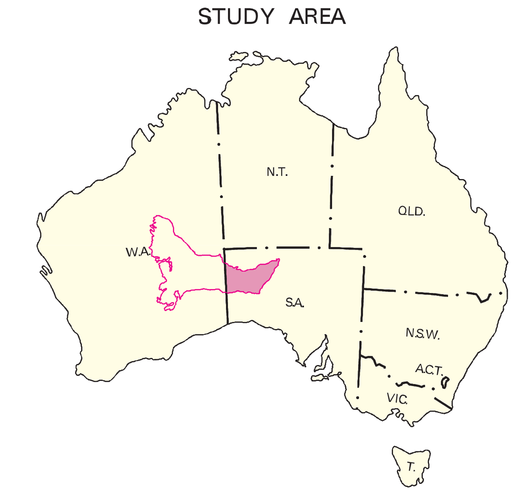
Published jointly by the Australian Geological Survey Organisation, Canberra, Australia and the Department of Mines and Energy, South Australia, as part of the National Geoscience Mapping Accord

It is recommended that this map be referred to as:
Lindsay,J.F., 1995 -
Isochron of Upper Ungoolya Group (Marinoan) (1:500 000)
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

STUDY AREA



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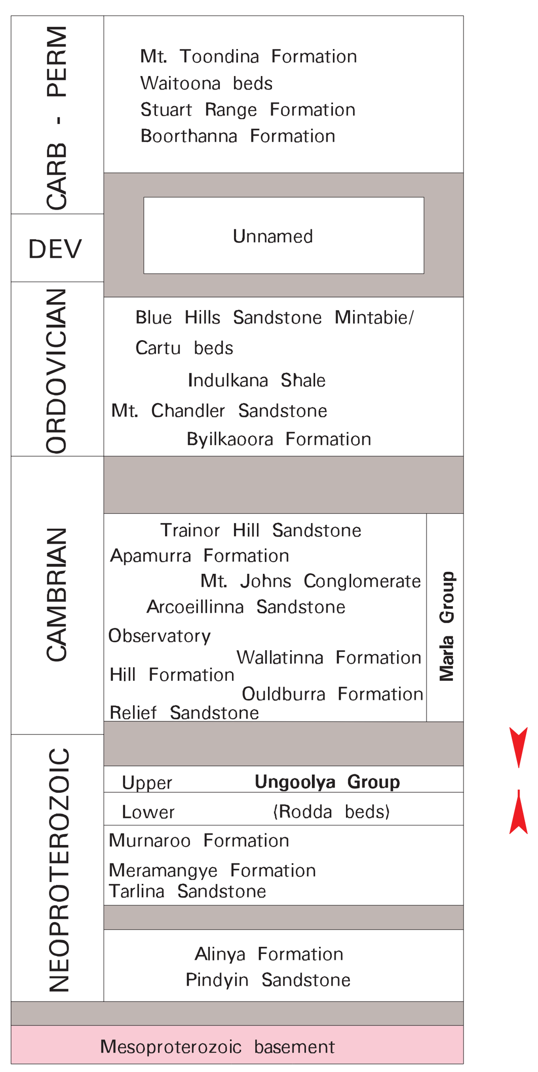
MINES AND ENERGY SOUTH AUSTRALIA



A submarine canyon-forming event (see Plate 24) on the northwest margin of the Murnaroo Platform which correlates with the Adelaide Geosyncline Wonoka canyons (Sukanta & others, 1991, Sukanta, 1993), divides the Ungoolya Group in two. Submarine canyons cutting down to the northwest have eroded locally to the level of the Meramangye Formation (Thomas, 1990). The upper Ungoolya Group comprises the canyon fill which locally exceeds 600m in thickness (Sukanta & others, 1991) plus the conformably overlying Munta Limestone and Mena Mudstone. Equivalents are the upper Rodda beds which outcrop and occur in Rodda #2 well near the northern margin of the basin (Preiss & Krieg, 1992). Recent work on acritarchs along with the erosion of the submarine canyons, provides firm correlations for this part of the section. The bulk of the Wright Hill beds and the overlying Punkerri Sandstone (2500+m) are equivalents of the upper Ungoolya Group in the Birksgate Sub-basin (Zang, 1993; in prep.). The upper Ungoolya Group correlates with the upper Wilpena Group in the Adelaide Geosyncline (Sukanta & others, 1991) and possibly with the Babbagoola beds in the western Officer Basin (Townson, 1985). Ediacaran fossil impressions have been found in the Punkerri Sandstone (Major, 1973) and also in the Stirling Range Formation north of Albany (Cruse & others, 1993).

Seismically, the upper Ungoolya Group forms a distinctive unit. The stacking patterns formed by depositional sequences above the canyon surface are markedly different from those below. Whereas the sequence boundaries are widely spaced below the canyon surface they are very closely spaced and close to seismic resolution above the surface. The abrupt change in architecture and depositional style appears to be a direct response to the onset of the Petermann Ranges Orogeny, a compressional event that affected the Officer Basin and the southern margin of the Amadeus Basin to the north. It is thus likely that the upper Ungoolya Group was deposited in a foreland basin setting.

Proterozoic sedimentation was slowed and eventually halted by uplift associated with the Petermann Ranges Orogeny. The depositional interval mapped on this plate is thus complex. Three and possibly four sequence boundaries can be identified seismically within the sedimentary package. All terminate abruptly by onlapping onto steeply dipping erosional surfaces along the Ammaroodinna Ridge or the major high developed in the vicinity of Munyarai #1 well, the Munyarai Anticline. Both the Ammaroodinna Ridge and the Munyarai Anticline grew significantly during the deposition of the upper Ungoolya Group. The growth was in large part tectonically induced but was amplified by the movement of salt from the underlying Alinya Formation into the structures. Early, deep-seated faults within the Mesoproterozoic basement appear to have been reactivated by the Petermann Ranges Orogeny. However, the faults do not disrupt the basin fill but simply form a monocline in the Munyarai area with the resultant strain being taken up by the lateral movement of approximately 150 ms (c. 360 m) of Alinya Formation evaporites into the high. The isochrons are thus complex providing evidence of thinning onto the Munyarai Anticline to the west and a total cessation of sedimentation across the Ammaroodinna Ridge to the south and southeast while showing a thickening wedge of sediment prograding towards the basin's northern margin. Superimposed upon the regional pattern of sedimentation are major anomalies in thickness associated with the canyons. The canyons contain up to 200 ms of additional fill. On some seismic sections sequences can be seen to backfill the major canyons.

The canyons all originate in the area around Ungoolya #1 and are diverted around the Munyarai Anticline where uplift was most pronounced and extend from these highs into the deep sub-basin. The canyons were probably initiated by slope failure over the rising salt-controlled structural high as sealevel fall exposed the area. Once initiated by slope failure the canyons then became conduits for sediments moving into the deep sub-basins from the eroding highs (Coleman & others, 1983). "Pull-ups" of seismic reflections associated with velocity anomalies on some seismic lines (e.g. line 74OF-E101) indicate that the lower parts of some canyons are filled with higher velocity lithologies presumably breccias of fine-grained carbonate blocks derived from the shelfal area similar to those encountered further east in the Wonoka canyons of the Adelaide Geosyncline (von der Borch & others, 1982, 1985) where megabreccia of metre-size micritic carbonate clasts are encountered (Jenkins & others, 1993).

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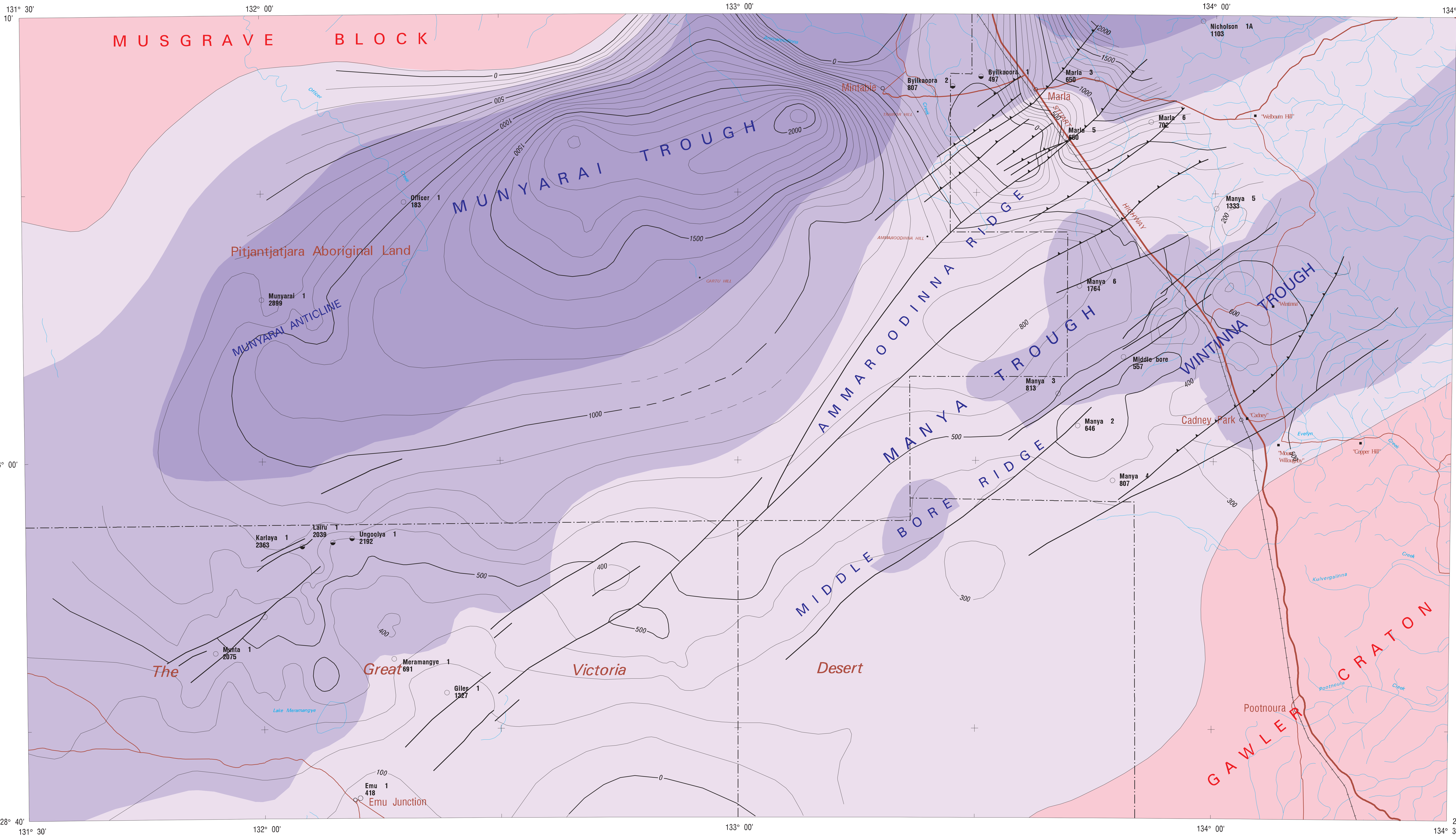
OFFICER BASIN

SOUTH AUSTRALIA

Depth to Precambrian-Cambrian Boundary

by J.F.Lindsay



Scale 1:500 000

10 0 10 20 30 40 50 kilometres

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

Index contour with value (ms)

Officer 1 183 — Petroleum exploration well with name and depth

Petroleum exploration well with show of oil

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

Compiled 1990-1994 by J.F.Lindsay, AGSO
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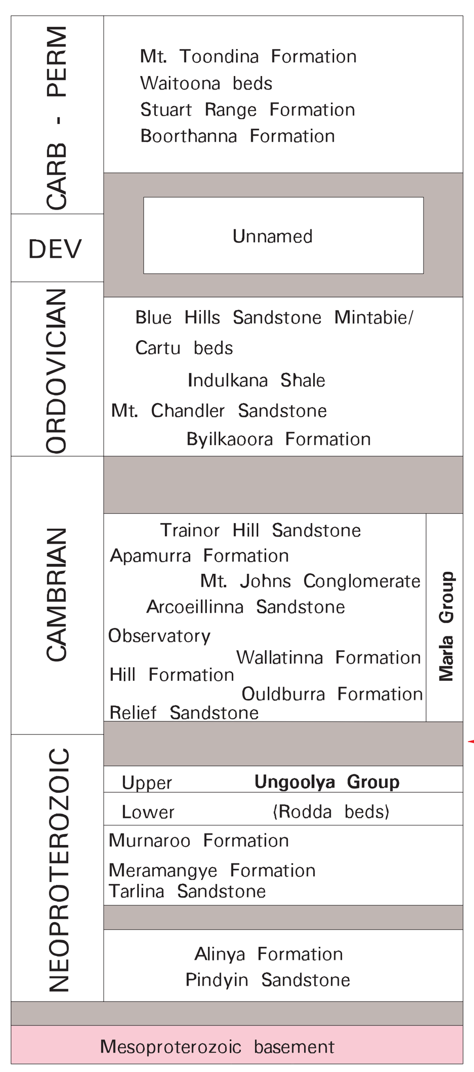

The Precambrian-Cambrian boundary surface in the eastern Officer Basin is a prominent erosional surface resulting from uplift associated with the Petermann Ranges Orogeny. Time structure contours on the boundary surface show that, following the orogeny, the basin entered a new evolutionary phase. During the early Marinoan subsidence was relatively rapid within the confines of the major sub-basins. Stacking patterns suggest that during the Cambrian the subsidence of the eastern Officer Basin had slowed considerably but had become much more regional such that sediments draped the Ammaroodinna Ridge and other prominent structural highs. While Cambrian sedimentation was relatively widespread the Munyarai Trough was reduced to a narrow feature along the northern margin of the basin. Even though the depth of the trough is still greater than 1 s (TWT) most of the space is filled by Ordovician and Devonian clastic foreland basin sediments generated during the Alice Springs Orogeny (see Plate 27). Time structure contours over the Ammaroodinna Ridge are relatively simple compared to deeper surfaces indicating that salt movement from the Alinya Formation had almost ceased by the beginning of the Cambrian. North of the Gawler Craton, the lower Cambrian surface steps down via normal faults to the Manya Trough. This trough presumably deepened in a northeasterly direction toward the Amadeus Basin. However, connections were severed by elevation of the Bitchera Ridge and Marla Overthrust Zone during the Alice Springs Orogeny. The broad regional subsidence during the Cambrian and the foundering of the basin's southern margin may simply relate to strain release at the end of the Petermann Ranges Orogeny however, evidence from the Amadeus Basin to the north suggests that the crust had been thinned in central Australia perhaps in response to extension (Lindsay & Korsch, 1989, 1991). It is evident from facies distributions in both the Amadeus and Officer Basins that the Petermann Ranges Orogeny had caused uplift of the Musgrave Block during the latest Neoproterozoic and that by Cambrian time the two basins were separate entities.

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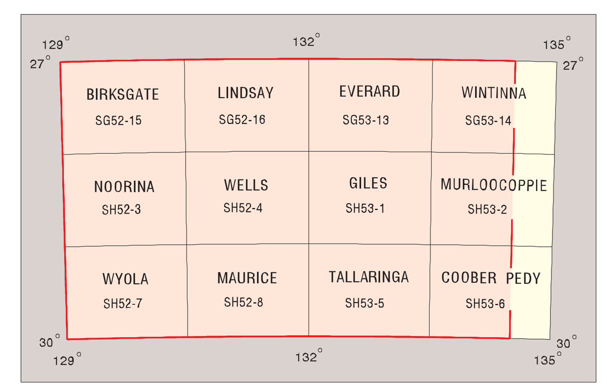

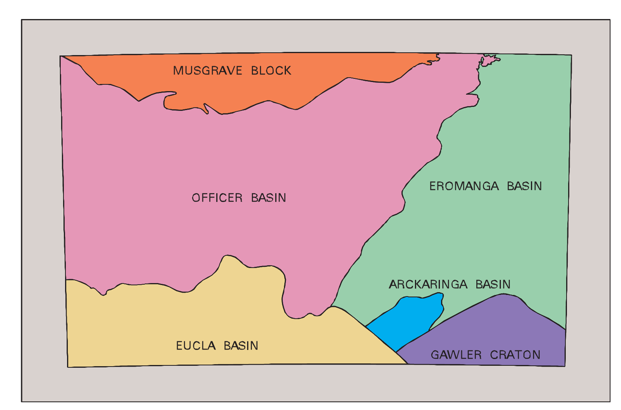

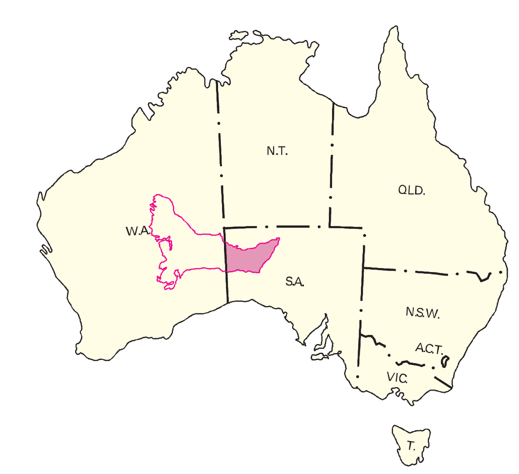

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MINES AND ENERGY SOUTH AUSTRALIA

GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 26

Depth to Precambrian-Cambrian Boundary

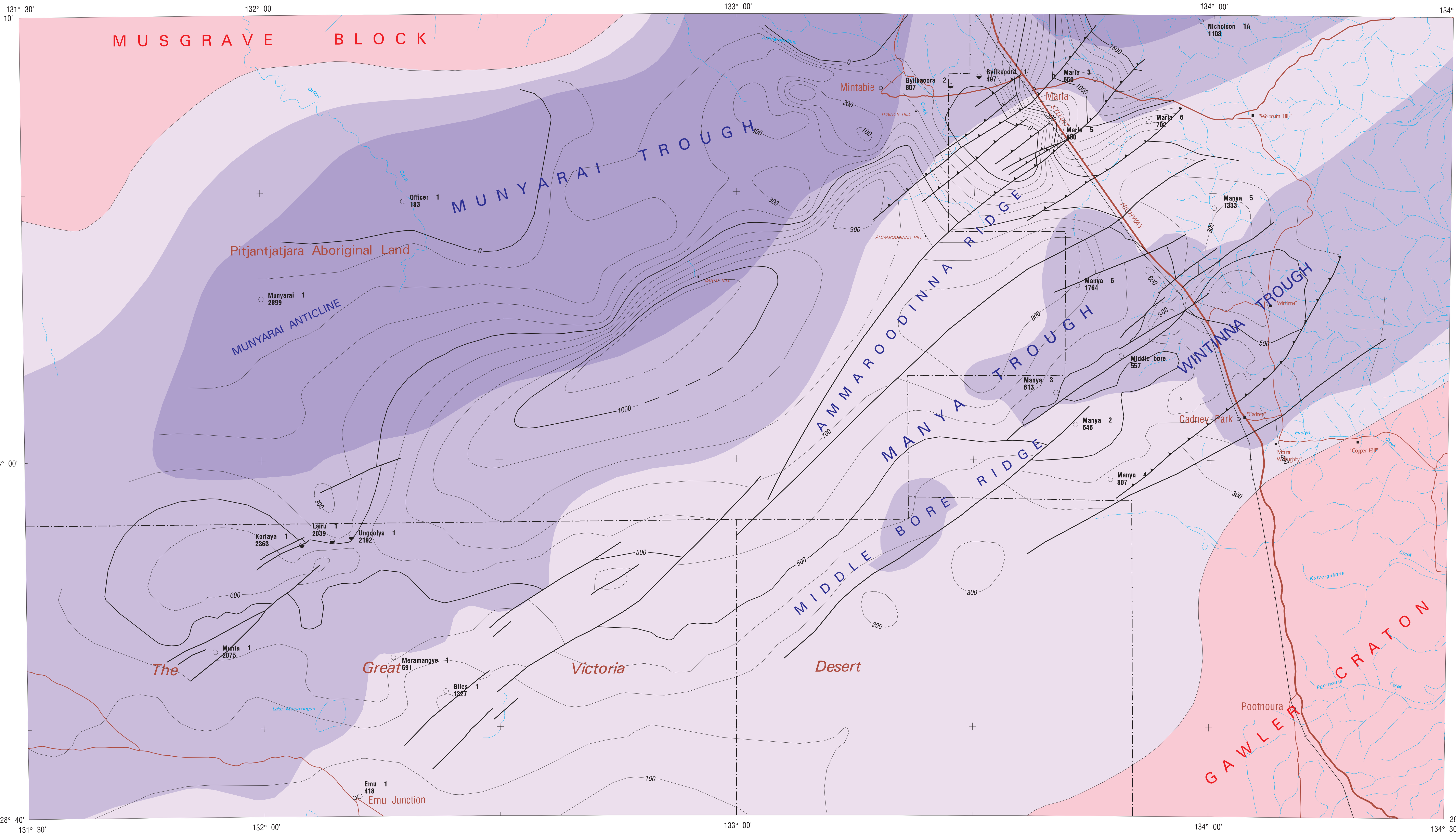
1995

OFFICER BASIN

SOUTH AUSTRALIA

Isochron of Cambrian Succession

by J.F.Lindsay, D.I.Gravestock



Scale 1:500 000

10 0 10 20 30 40 50 kilometres

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

—1000— Index contour with value (ms)

Officer 1 / 183 — Petroleum exploration well with name and depth

Petroleum exploration well with show of oil

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

Compiled 1990-1994 by J.F.Lindsay, AGSO
Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
Data processing by K.Reine, AGSO using Petrosys software
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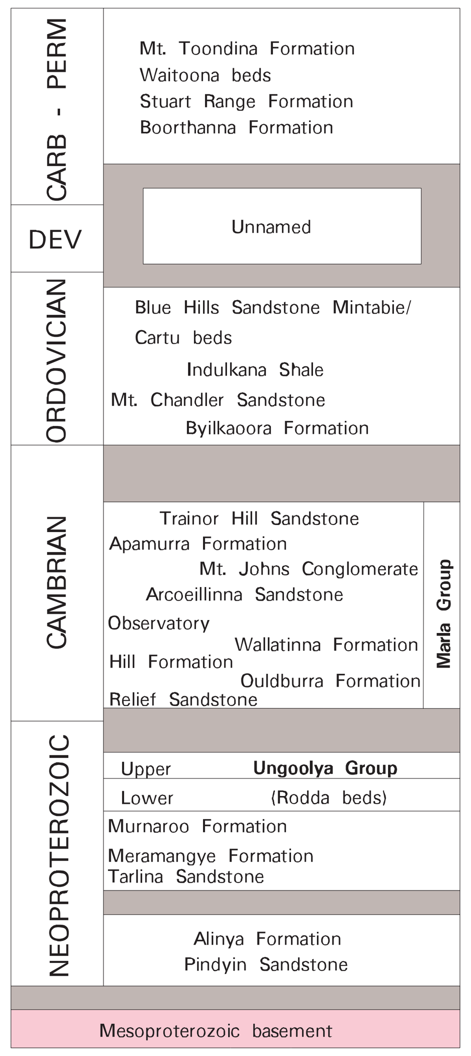

The disruptive local tectonism and associated salt movement that characterised the latest Neoproterozoic appears to have largely ceased in the eastern Officer Basin by the beginning of the Cambrian. Seismically, the Cambrian rocks of the eastern Officer Basin appear over a wide area as closely spaced parallel reflections draped over the deformed Neoproterozoic section. This implies that the Cambrian rocks consist of thin stacked depositional sequences deposited in a slowly subsiding basin. The geometry of the package is, however, different from earlier time intervals in that it thins towards the basin's northern margin and is thickest (ca. 800 ms) along the margin of the Murnaroo Platform. In part this geometry reflects later erosion during the Delamerian and Alice Springs Orogenies but it also suggests that accommodation was quite restricted during much of the early Palaeozoic. The southern margin of the package is clearly erosional although the original southward extent of Cambrian sedimentation is not known. This time interval contrasts sharply with the situation in the Amadeus Basin to the north where the Cambrian period was characterised by extensional tectonics and the reactivation of major sub-basins along the northern margin of the basin (Lindsay & Korsch, 1989; 1991; Lindsay, 1993).

The Cambrian section has been divided into at least nine lithostratigraphic units that can be recognised over considerable areas of the eastern Officer Basin. Gravestock & Hibburt (1991) identified at least five deposition intervals within the lithostratigraphic units which they referred to as sequence sets or supersequences. The first three sequences (C1.1 to C1.3) in the basal sequence set consist in part of the Relief Sandstone, a fine to coarse grained pale red silica-cemented feldspathic sandstone. This unit appears to be diachronous and spreads into the hinterland across all three younger sequences. The first of these sequences (C1.1) consists of the lower part of the Relief Sandstone. In the extreme eastern end of the basin aeolian and fluvial facies have been identified in the transgressive systems tract of this sequence suggesting that the area consisted of a mosaic of isolated salinas on shallow mudflats bordered by aeolian dunes and fluvial settings (Gravestock & Hibburt, 1991; Gaughan & Warren, 1990; Gaughan, 1989). In the same area archaeocyath-calcimicrobe buildups characterise the shallow marine transgressive systems tract (Dunster, 1987; Brewer & others, 1987). Trilobites within the transgressive and highstand systems tracts belong to a new species of *Abadiella* and indicate a middle Early Cambrian (late Atdabanian-Botomian) age (Jago & Youngs, 1980). Carbonate breccias with trilobites at the top of the unit provide evidence of subaerial exposure (Jago & Youngs, 1980) which appears to represent the sequence boundary. The boundary can be tied to a well defined seismic reflection (Dunster, 1987).

The second sequence set (C1.2 of Gravestock & Hibburt, 1991) represents a major transgression. This sequence combines part of the diachronous Relief Sandstones and the Ouldburra Formation. In the Manya Trough the Ouldburra Formation is a mixed carbonate siliciclastic unit consisting of numerous parasequences represented by upward shallowing carbonate/clastic cycles (Dunster, 1987). Further southwest reworked sandstones and conglomerate with limestone mudclasts and ooids suggest a marine setting (Gatehouse & Hibburt, 1987; Gaughan, 1989; Gaughan & Warren, 1990; Gravestock & Hibburt, 1991). Sukanta (1993) however, considers the ooids to be in clasts reworked from the Neoproterozoic Wilari Dolomite.

The third sequence set (C1.3 of Gravestock & Hibburt, 1991) consists of the upper parts of the Relief Sandstone, the upper Ouldburra Formation. Its presumed lateral equivalent in the Birksgate Sub-basin to the west (Gravestock & Hibburt, 1991) is now known to be Neoproterozoic in age.The upper Ouldburra Formation consists of a regressive package of upward shoaling parasequences (Dunster, 1987; Gravestock & Hibburt, 1991). The Relief Sandstone appears to be fluvial over large areas (Gaughan, 1989; Gaughan & Warren, 1990). This sequence set appears to indicate a period of regional regression.

The fourth Cambrian sequence set (C2.1 of Gravestock and Hibburt, 1991) includes the Wallatinna Formation, Arcoeillinna Sandstone and Observatory Hill Formation. The Observatory Hill Formation comprises the main body of sediment accumulated during this time period and consists of red-brown, micaceous siltstone and claystone, gray dolostone, dolomitic limestone and some fine-grained sandstone. Three horizons within the formation contain evaporite pseudomorphs and in some cases desiccation cracks, chert nodules and other evaporitic structures (Brewer & others, 1987). The unit was deposited in a fluvial and playa lake setting (Pitt & others, 1980; White & Youngs, 1980; Brewer & others, 1987; Stainton & others, 1988; Southgate & others, 1989). Laterally and locally the Observatory Hill Formation is replaced by the Wallatinna Formation which consists of thinly bedded, coarse to granule arkose and interbedded red-brown to green siltstones. The Wallatinna Formation was deposited in an alluvial fan setting which interfingers laterally with the playa setting of the Observatory Hill Formation. The Arcoeillinna Sandstone consists of red-brown to white cross bedded arkosic and micaceous sandstone with thin siltstone and claystone interbeds which were deposited in a fluvial setting that gradually replaced the underlying playa settings of the Observatory Hill Formation (Benbow, 1982; Gravestock & Hibburt, 1991).

The later Cambrian rocks of the eastern Officer Basin appear to belong to a single depositional sequence. The sequence consists of the Apamurra Formation and the Mount Johns Conglomerate (Krieg, 1973; Benbow, 1982) which forms the transgressive systems tract overlain by the Trainor Hill Sandstone which forms the highstand systems tract. The Apamurra Formation consists of red-brown dolomitic siltstones and sandstones overlying a basal conglomerate. The unit appears to be fluvial in origin and to interfinger laterally with the red polymict conglomerates of the Mount Johns Conglomerate which was deposited in a fan-delta setting on the basin margin. The Trainor Hill Sandstone consists of well sorted fine to medium-grained crossbedded sandstones which form a deltaic to shallow marine highstand.

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Prospectivity

Cambrian reservoirs are most likely to be located in thrust-associated anticlines and strike-slip structures produced during the Alice Springs Orogeny. In the Munta area decollement appears to have occurred within the Proterozoic evaporites of the Alinya Formation, whilst as the sequence thins to the east the faulting produces large over-thrust structures as part of the Marla Overthrust Zone (Gravestock, 1994).

The source rock potential of the early Palaeozoic units of the eastern Officer Basin is relatively limited. The Cambrian Ouldburra Formation, primarily a platform carbonate, has variable TOC values from 0.04 to 1.87%. The richest potential source beds are thin (_I m) but widespread and appear to be concentrated in sabkha and highstand sediments. Kerogen is of poor quality and mature to overmature in the northeast part of the basin, but good quality Type II kerogen in the main oil generative window (VRcalc = 0.8%) occurs in the Tallaringa Trough. Oil staining resulting from migrating hydrocarbons has been seen in Observatory Hill #1 well (Gatehouse & Hibburt, 1987), Wilkinson #1 (Gatehouse, 1979) and Manya #6 (see Plate 5) (Gravestock,1994).

A quite distinct oil family occurs in the non-marine, alkaline playa lake sediments of the Observatory Hill Formation. Nine mineral drillholes recorded oil bleeds and oil stains in vugs and fractures from depths as shallow as 200m below surface. TOC values of the host carbonate range from 0.5 to 1.4%, calculated vitrinite reflectance places the Byilkaoora #1 intersection in the oil window (VRcalc = 0.9-1.0). The playa lake facies (Parakeelya Alkali Member) extends for 200 km along the Manya Trough, reaching the surface at Observatory Hill #1.

Potential reservoir rocks are widespread in the early Palaeozoic units of the eastern Officer Basin although seals are not always present. The Relief Sandstone disconformably overlies the Proterozoic in the Manya Trough. Aeolian, fluvial and tidal facies are related to marine lowstand-highstand cycles. Porosity is variable and related to burial depths reached during the Alice Springs Orogeny. Footwall situations average 2.9%, hanging wall situations 6.7%, and areas distant from the Marla Overthrust Zone average 16.4%, with permeability up to 8 darcies resulting from dissolution of clay and carbonate cements.

Relief-type sandstones are interbedded with Ouldburra lowstand deposits (porosity 1-23%, permeability 0.01 - 596 md). Intercrystalline porosity and permeability of Ouldburra dolomites are superior (6-23%, 23-1640 md) thus this unit has both source and reservoir potential.

The Cambrian Arcoeillinna and Trainor Hill Sandstones extend through the Manya and Munyarai Troughs and onto the Murnaroo Platform. The Arcoeillinna Sandstone is an immature, muddy micaceous arkose with poor to excellent reservoir properties. Average porosity is high (>13%) and permeability ranges from 0.1 to 1700 md.

The Trainor Hill Sandstone is fine grained, usually quartzose, with average porosity of 15% and permeability in the tens to hundred millidarcy range. Thickness of this sandstone is variable owing to Delamerian erosion.

It is recommended that this map be referred to as:
Lindsay,J.F., Gravestock,D., 1995 -
Isochron of Cambrian Succession (1:500 000)
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

STUDY AREA

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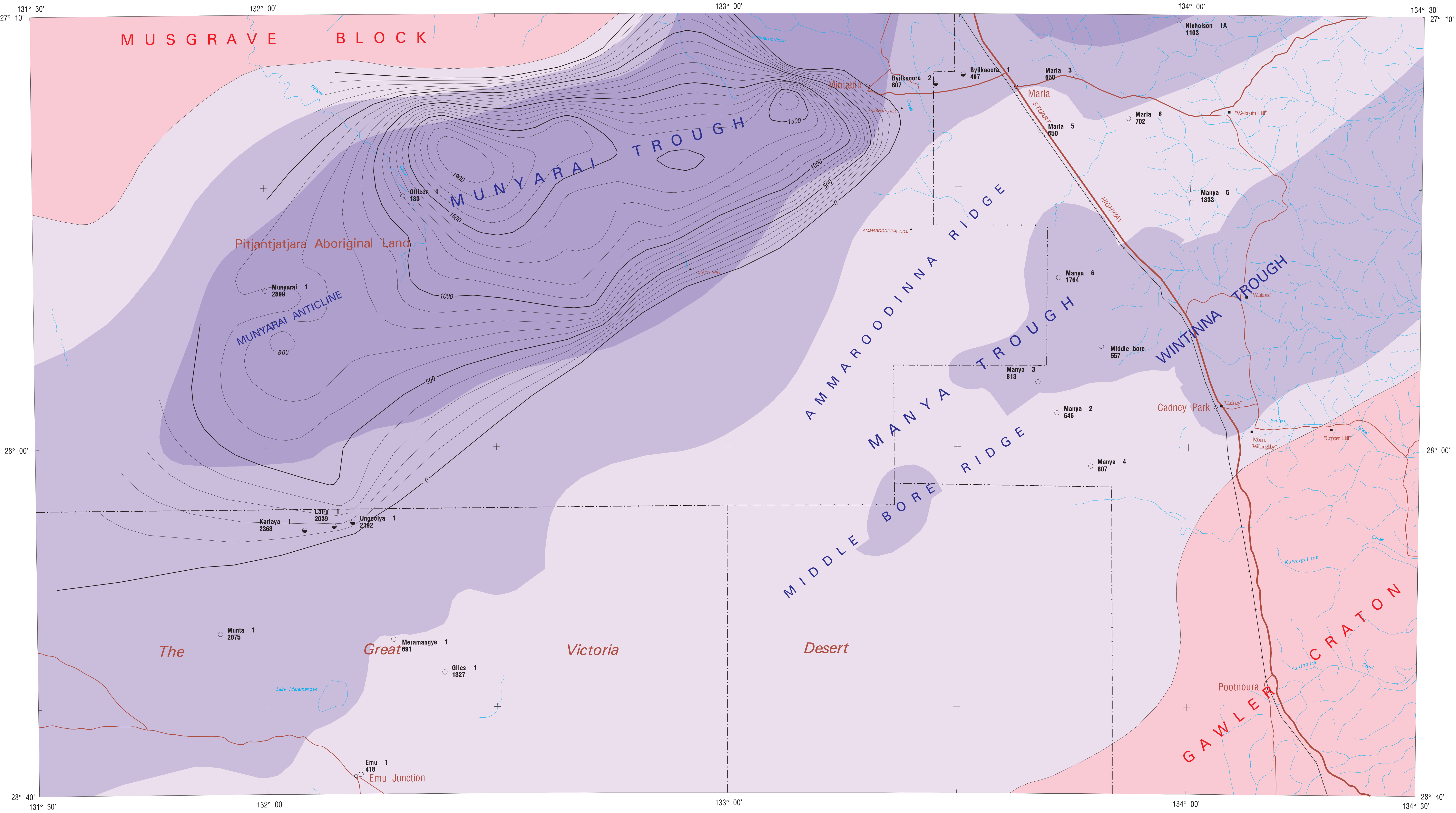
MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 27

Isochron of Cambrian Succession

1995



OFFICER BASIN
SOUTH AUSTRALIA
Depth to Delamerian Erosion Surface (Cambro-Ordovician)

by J.F.Lindsay

Scale 1:500 000

10 0 10 20 30 40 50 kilometres

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E

Fault

Thrust fault. Triangle on older rocks

Contour

—1000— *Index contour with value (ms)*

Officer 1 183 ○ *Petroleum exploration well with name and depth*

Petroleum exploration well with show of oil

Crystalline basement

TWT basement

0 - 1000ms

1000 - 2000ms

> 2000ms

Compiled 1990-1994 by J.F.Lindsay, AGSO
Edited by D.Palfreyman, AGSO; W.Preiss, C.Gatehouse, MESA
Data processing by K.Reine, AGSO using Petrosys software
Cartography by A.J.Retter, AGSO
Produced by AGSO Cartographic Services Unit using Arcinfo software

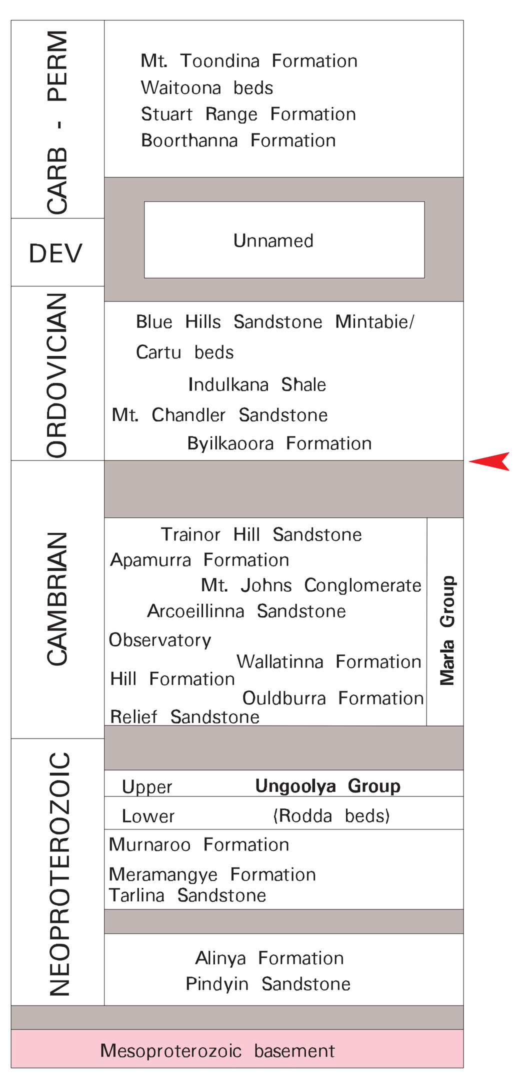
Topographic detail based on information supplied by the Department of Environment and Natural Resources, South Australia.

Parks and Reserves supplied by Department of Housing and Urban Development, South Australia

Published jointly by the Australian Geological Survey Organisation, Canberra, Australia and the Department of Mines and Energy, South Australia, Adelaide, as part of the National Geoscience Mapping Accord

It is recommended that this map be referred to as:
Lindsay,J.F., 1995 -
Depth to Delamerian Erosion Surface (Cambro-Ordovician (1:500 000)
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

STUDY AREA



The post-Cambrian Officer Basin developed primarily under a compressional regime. Two events, the Delamerian and Alice Springs Orogenies, had a major effect on the basin architecture. The Delamerian Orogeny was the less intense of these two events as its main effects were in the Adelaide Geosyncline. Despite this, the Delamerian Orogeny played a major role in basin evolution, as can be seen from the surface mapped here. The erosion surface represents a considerable period of time during which much of the Cambrian and some Neoproterozoic rocks were eroded (see Plate 26). The foreland basin became a long narrow east-west trending structure which, for much of its early development, appears to have been a major drainage conduit transporting eroded earlier Cambrian sedimentary materials to the continental margin. Ultimately, increased subsidence and rising sealevel resulted in the deposition of two relatively shallow marine depositional sequences along the basin axis.

The first Ordovician sequence consists of the Byilkaoora Formation (Benbow, 1982) and the lower part of the Mount Chandler Sandstone (Krieg, 1972, 1973). The Byilkaoora Formation is exposed only in the Mount Johns Range and consists of white feldspathic (kaolinitic) crossbedded sandstone which overlies a basal conglomerate. The Mount Chandler Sandstone consists of fine to medium, well sorted, occasionally crossbedded, sandstone which is white and quartzose lower in the formation. The formation becomes red and a little feldspathic towards the top and there is a change to a more blocky log character in Munyarai #1 well suggesting that the upper part of the unit forms part of the next sequence. The unit is burrowed and contains abundant *Scolithus* and *Diplocriterion* and has been interpreted as being deposited in a shallow marine deltaic and barrier beach environment (Krieg, 1972, 1973; Stainton & others, 1988).

The second of the Ordovician sequences consist of part of the upper Mount Chandler Sandstone and three lithologic units, the Indulkana Shale the Blue Hills Sandstone and the Cartu beds. The change in the gamma ray log character of the sandstones in the upper part of the Mount Chandler Sandstone suggests that they form the transgressive systems tract of the final deposition sequence. The other alternative is that the upper Mount Chandler Sandstone unit forms a separate sequence in its own right. The Indulkana Shale consists largely of grey green shale with occasional thin limestone beds and fine sandstone units. The Blue Hills Sandstone consists of well sorted, fine to medium red sandstone that have well developed large-scale trough cross-bedding and occasional pebbly lenses and rare signs of bioturbation. The Cartu beds are texturally similar to the underlying unit but contain interbeds of biotite-rich red shale. The three units appear to form a generally shallow marine succession which is overall upward shoaling and to form a highstand systems tract.

The final phase of basin evolution in the Officer Basin was, as in the Amadeus Basin, a major compressional event, the Alice Springs Orogeny (Lindsay & Korsch, 1989, 1991). The northern margin of the Officer Basin is in part a homoclinal upturn resulting from the rotation or roll back of the older sedimentary basin fill in front of a north dipping thrust complex. The homocline appears to extend along much of the length of the basin's northern margin. However, in the vicinity of longitude 133° 40' E in the Marla Overthrust Zone (Gravestock & Lindsay, in press) the structural style changes and thrusting within the basement rocks breaks through the overlying Officer Basin succession to form a series of thin en echelon thrust sheets which indicate a local foreshortening of the crust by as much as 30 percent (see Plate 3).

The Devonian rocks of the eastern Officer Basin have only been intersected in one well, Munyarai #1, in the southern Munyarai Trough where they form at least 800 m of the succession. Seismically, they can be seen to form the bulk of the succession that accumulated in the foreland basin phase of the Officer Basin's development. The seismic data show that the succession is complex and includes a number of major disconformities suggesting that the evolution of the foreland basin phase was similar to that of the Amadeus Basin. The Devonian rocks in Munyarai #1 well consist of a lower suite of interbedded sandstones and olive green mudstones and an upper suite of sandstones and redbeds. Fish remains from the mudstone succession have yielded a Middle Devonian (Eifelian) age (Long & others, 1988) whereas palynomorphs suggest a Late Devonian (Frasnian) age (Womer & others, 1987). The sandstones are generally red brown, fine to coarse grained and micaceous although some units are grey and a few units have small-scale cross beds. Typically they occur in beds 15 to 20 cm thick. The interbedded mudstones are red-brown or less frequently, grey-green or black with well developed partings. They frequently occur as thin laminae within the sandstones although some mudstone beds up to 30 cm thick are present. Traces of fibrous gypsum, probably derived from veins in the sandstones, occurs in cuttings throughout the upper part of the Devonian section. Recent studies suggest that the Waitoona beds partly intersected by the Officer #1 well and thought to be Carboniferous or Devonian (Krieg, 1972, 1973), may be Early Permian while the Mintabie beds are may be Early Ordovician (Gravestock & Lindsay, in press). An alternative possibility is that the Mintabie beds correlate with a labile sandstone interval in the upper part of the Devonian units intersected by Munyarai #1.

The Devonian succession appears to have been deposited in a fluvial and freshwater lacustrine setting or as evaporitic red beds. It accumulated in a narrow east-west trending foreland basin that developed due to crustal loading ahead of the advancing thrust sheets during the Alice Springs Orogeny. The setting is very similar to the Amadeus Basin except that the resulting sediments shed from the advancing thrust sheets on the northern margin of the Officer Basin appear to have been finer grained. However, knowledge of the Devonian units is very limited and locally, such as at the Blue Hill locality, coarse arkoses are encountered. Seismic data show that the foreland basin extends to a depth of 1.8 s (TWT) in the deepest, northern part of the Munyarai Trough.

Prospectivity

The Ordovician Mount Chandler Sandstone (porosity 12.7-19.7%, permeability 0.26-238 md) is a clean quartzose sandstone. Reservoir potential is good but due to its stratigraphic position the Mount Chandler risks lack of seal resulting from Permian erosion. However, it presents an excellent footwall target in overthrust zones (Gravestock,1994) and locally the Indulkana Shale may form an effective seal. Given the experience in the Amadeus Basin, where the Mereenie Sandstone forms a prominent aquifer, the interval may also have considerable potential as a source of water.

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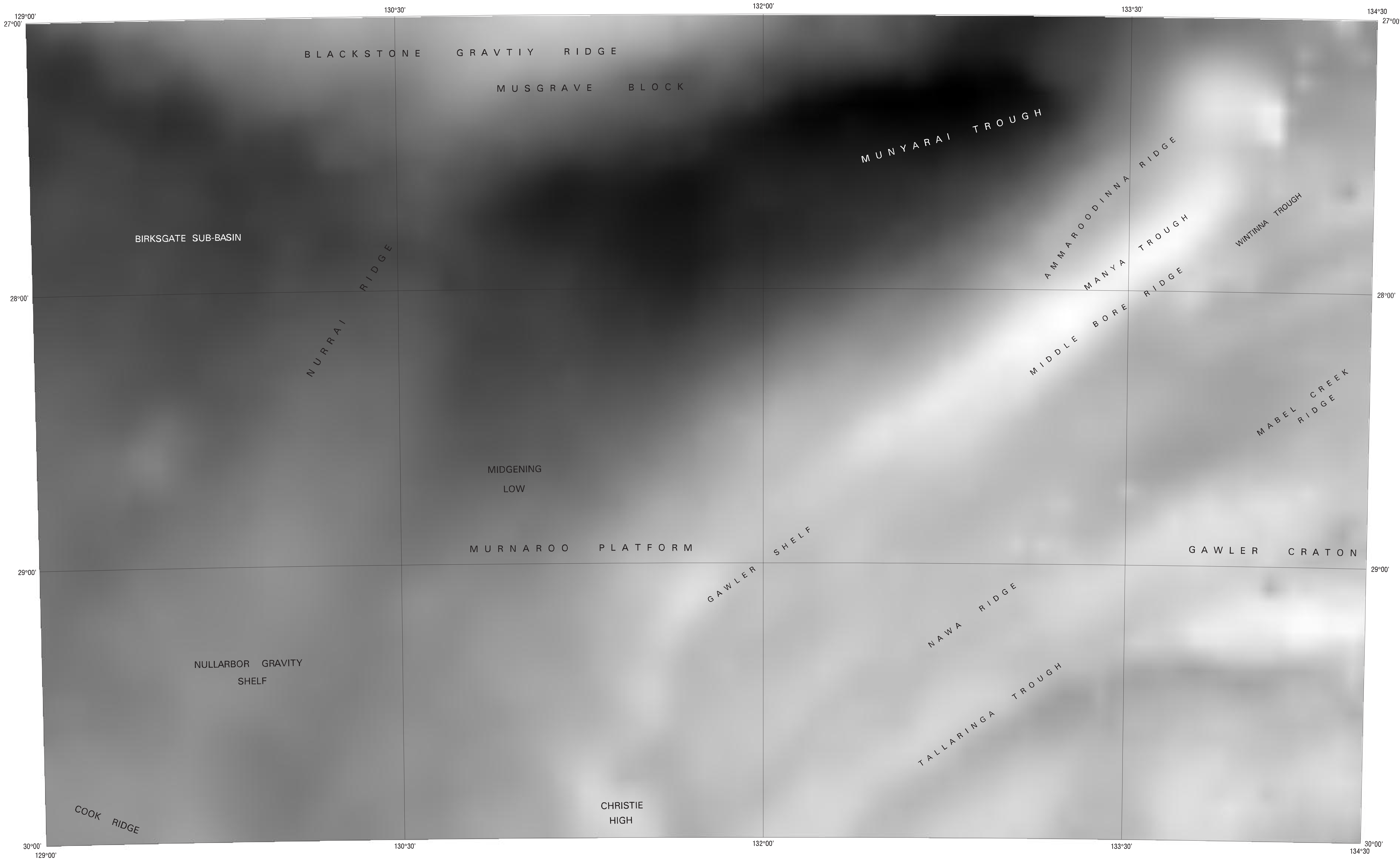

OFFICER BASIN

SOUTH AUSTRALIA

Bouguer Gravity Anomaly Image

by J.Leven

Scale 1:1 000 000

20 0 20 40 60 80 100 kilometres

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S

Central meridian 132°00'E

The Officer Basin in South Australia is covered by the National Gravity Grid (Barlow, 1970; Morse & others, 1992), where gravity values have been recorded on an approximate 5 km grid. The Bouguer gravity data provide a clear picture of the Officer Basin's morphology which is represented regionally by negative Bouguer anomaly values. In South Australia, this basin is bounded by the Musgrave Block to the north, the Gawler Craton to the south-east marked by a ridge of positive anomalies, and to the south, by the Coompana Block which is also characterised by higher Bouguer anomaly values. Bouguer gravity data have been used to sub-divide the basin into provinces having a similar anomaly character, and these are named following the nomenclature of Ashley (1984).

Strong negative anomalies (black) indicate an arcuate geometry of deep troughs which border the southern edge of the Musgrave Block. The Birksgate Gravity Low in the west is separated from the Munyarai Gravity Low by the Nurrai Gravity Ridge. The Munyarai Low is pinched to the east between the dominantly east-west Blackstone Gravity Ridge of the Musgrave Block and the north-east trending Gawler Shelf which parallels the edge of the Gawler Craton. South of the Birksgate and Munyarai Lows, the gravity values increase onto the Nullarbor Regional Gravity Shelf, where subtle anomalies have trends which are predominantly north-northeast, in concordance with the Nurrai Gravity Ridge and the western edge of the Gawler Block. The Midgening Low is bounded between the Nurrai Ridge and the Gawler Shelf. At the south-western limit of this image, the northern portion of northwest trending Cook Ridge is just evident, as is portion of the Chrisite High.

Seismic line 93AGSL4 (Plate 11) crosses the Nurrai Ridge gravity anomaly. The flat-lying structure and relatively constant thickness (1200 ms TWT or approx. 2500 m) of the basin sediments across this gravity feature indicate that the source of this gravity anomaly is not related to a basement ridge. The increased density responsible for this gravity anomaly is therefore located deeper, within basement, although the deeper seismic data gives no clear indication of its source.

Seismic data from line 93AGSL1 (Plate 11) together with the coincident gravity data provide a clear image of the marginal structure of the southern Musgrave Block and the northern Officer Basin of western South Australia, (Leven & Lindsay, in prep.). The data show that the Officer Basin and the Musgrave Block are underlain by a series of pervasive, north-dipping planar structures that predate development of the Officer Basin. Reactivation of these structures formed a thrust fault complex and folded portion of the Officer Basin succession into a major homocline at the northern margin of the basin.

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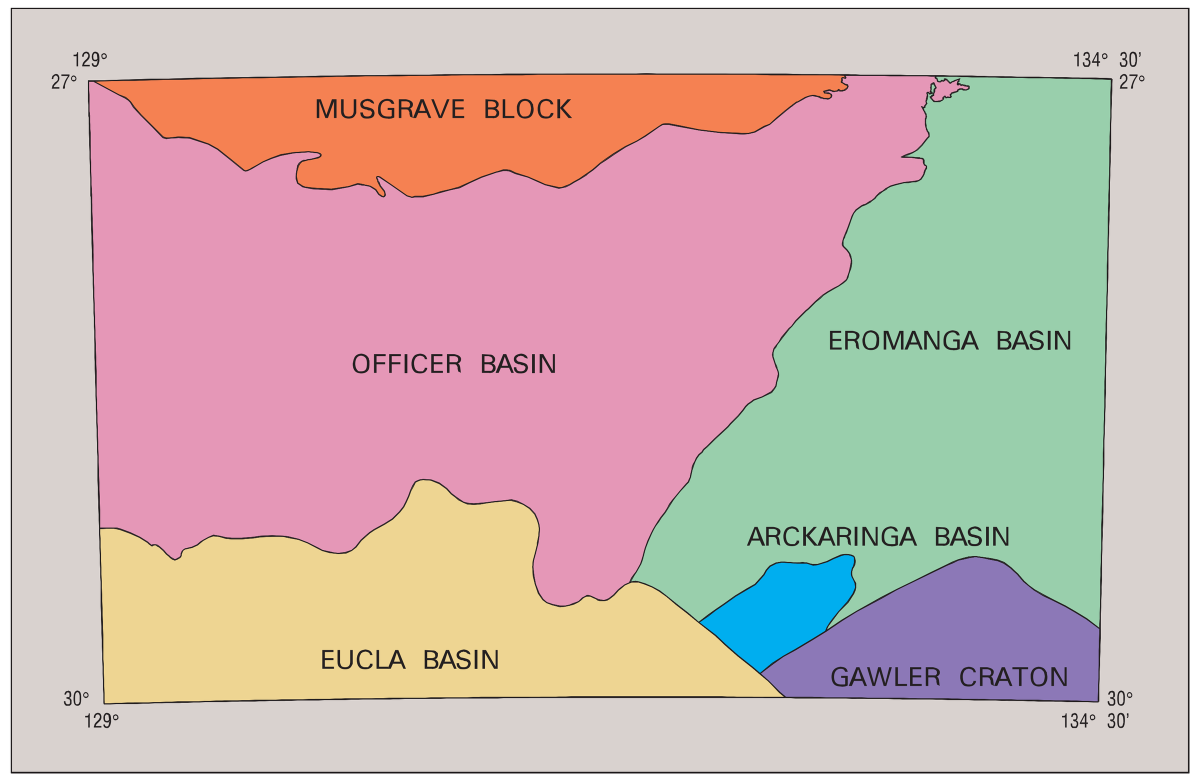
Compiled 1994 by J.H.Leven, AGSO
Edited by D.Palfreyman, AGSO
Data from the Australian National Gravity Database 1992, collected by the Gravity Group, AGSO, and processed by A.Murray
Cartography by A.J.Retter, AGSO
Produced by AGSO Cartographic Services Unit using Arcinfo software

Published jointly by the Australian Geological Survey Organisation, Canberra, Australia and the Department of Mines and Energy, South Australia, Adelaide, as part of the National Geoscience Mapping Accord

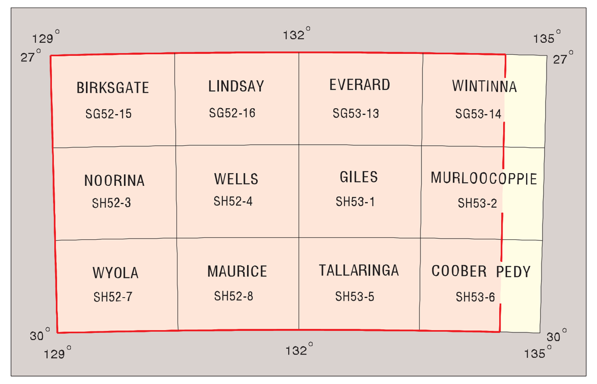
It is recommended that this map be referred to as:
Leven,J.H., 1995 -
Bouguer Gravity Anomaly Image (1:1 000 000)
In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

LOCALITY PLAN

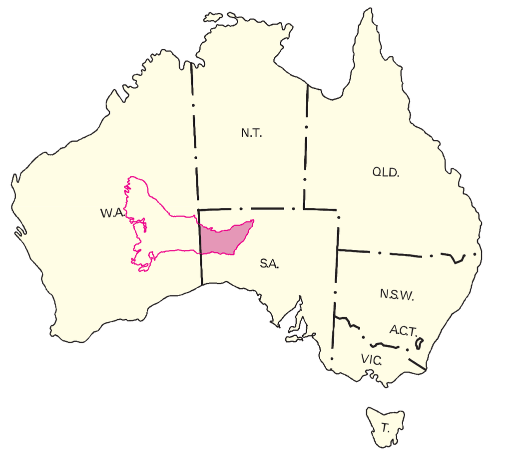
GEOLOGICAL PROVINCES
Showing margins of Basin Outcrop



INDEX TO 1:250 000 MAPS



STUDY AREA



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AGSO AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

MINES AND ENERGY SOUTH AUSTRALIA

OFFICER BASIN

SOUTH AUSTRALIA

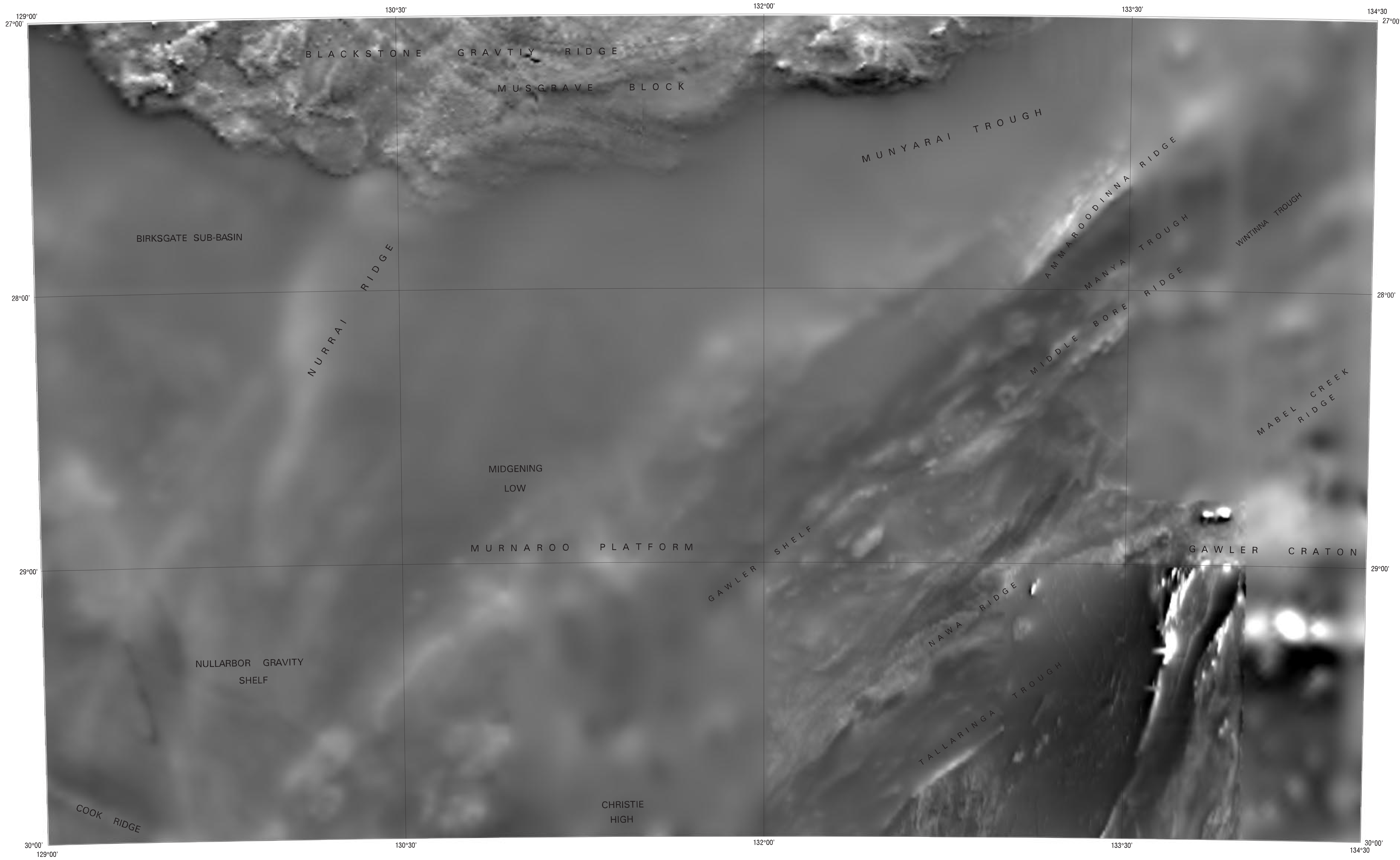
Total Magnetic Intensity Image

by J.Leven

Scale 1:1 000 000

20 0 20 40 60 80 100 kilometres

Lambert Conformal Projection
Standard parallels 27°15'S 30°15'S
Central meridian 132°00'E



Regional aeromagnetic data have been acquired over most of the Officer Basin by the Bureau of Mineral Resources (now AGSO) surveys from 1969 to 1982. Flight line spacing varies according to the vintage of the data, and ranges from around 3 km in the basin and on the northeastern region to 1.6 km in the Musgrave and Gawler basement areas. The total magnetic intensity data have been levelled and grided (Tarlowski & others, 1993) to produce a total magnetic intensity (TMI) image of the area. The TMI grided data give an image of the overall morphology of the Officer Basin.

The potential field data have been used to sub-divide the basin into provinces having a similar anomaly character, and these are named following the nomenclature of Ashley (1984). The Officer Basin is characterised on the TMI as having a lower wavenumber and more subdued expression than the surrounding basement blocks. The Musgrave Block is clearly evident on the TMI image as the northern boundary of the Officer Basin, and to the southeast, the Gawler Craton is also seen as an area of higher wavenumber anomalies.

Officer Basin

Within South Australia, the TMI image of the Officer Basin displays a fan-like structure, with three linear anomalies which appear to splay north from the Coompana Block, which lies south of the area of this plate. The western ridge trends NNW close to the SA/WA border; the central ridge corresponds to the Nurrai Gravity Ridge, the eastern ridge corresponds to the Gawler Shelf. The Officer Basin is sub-divided by these "ridges" into the Birksgate Trough in the west and the Munyarai Trough in the east, with both these troughs having a relative negative and subdued magnetic signature.

The NNE trending Nurrai Ridge anomaly separates the Birksgate and Munyarai troughs, gives the appearance of extending into (or beneath) the Musgrave Block, and appears to bifurcate south of 28° 20'S. As discussed in the gravity image (Plate 29), 93AGSL4 crosses the Nurrai Ridge feature, and the seismic data indicate that the source of this gravity anomaly must be located within the basement. The seismic data of 93AGSL4 shows no indication of a volcanic source for the magnetic anomaly in sedimentary succession.

The Gawler Shelf is comprised of a series of ridges and troughs which parallel the NW margin of the Gawler Craton. The basement structure of this shelf in the eastern Officer Basin has been mapped using the available seismic data (Plate 11), but a large section of this shelf is unknown. The southern end of seismic line 93AGSL5 extends onto the Gawler Shelf, and shows slight folding of the sedimentary sequence, and some minor faulting. However, there is no evidence of development of substantial ridges and troughs in the basement on line 93AGSL5, as seen farther northeast.

The network of 1993 AGSO seismic lines show the central Officer Basin to have a simple, virtually undisturbed structure away from the boundary with the Musgrave Block and Gawler Craton. Leven & Lindsay (1992) applied edge-enhancement and filtering techniques to the TMI grided data, in order to interpret the lower amplitude and longer spatial wavelength anomalies of the potential field data over the sedimentary basin. By correlating these enhanced anomalies with structure observed in the seismic data, the character of the TMI anomalies which are associated with structure in the sedimentary section can be distinguished. Nearly all the basement-involved faults, interpreted using the seismic data in the eastern Officer Basin, correlate and are conformable with the structure in the enhanced TMI image. Furthermore, some TMI anomalies are associated with structural disturbance within the sedimentary section, for example, the major diapiric piercement wall in the eastern Officer Basin.

Musgrave Block

Strong east-west arcuate lineations are clearly distinguishable in the Musgrave Block, and correspond to major faults. A more subtle, but relatively pervasive south-easterly trending suite of lineaments is observed in the TMI image in the south and western portion of the Musgrave Block. The southern margin of the Musgrave Block displays prominent changes in character along its length, suggesting that this bounding fault may vary in its structural style along the northern margin of the Officer Basin.

Gawler Craton

The northwestern edge of the Gawler Craton is characterised on the TMI image with NE-SW trending lineaments which parallel this boundary of the Officer Basin, suggesting that this edge of the craton pre-dated the development of the Officer Basin. More recent aeromagnetic data, collected as part of the SA Exploration Initiative gives better definition of the structure of the Gawler Block.

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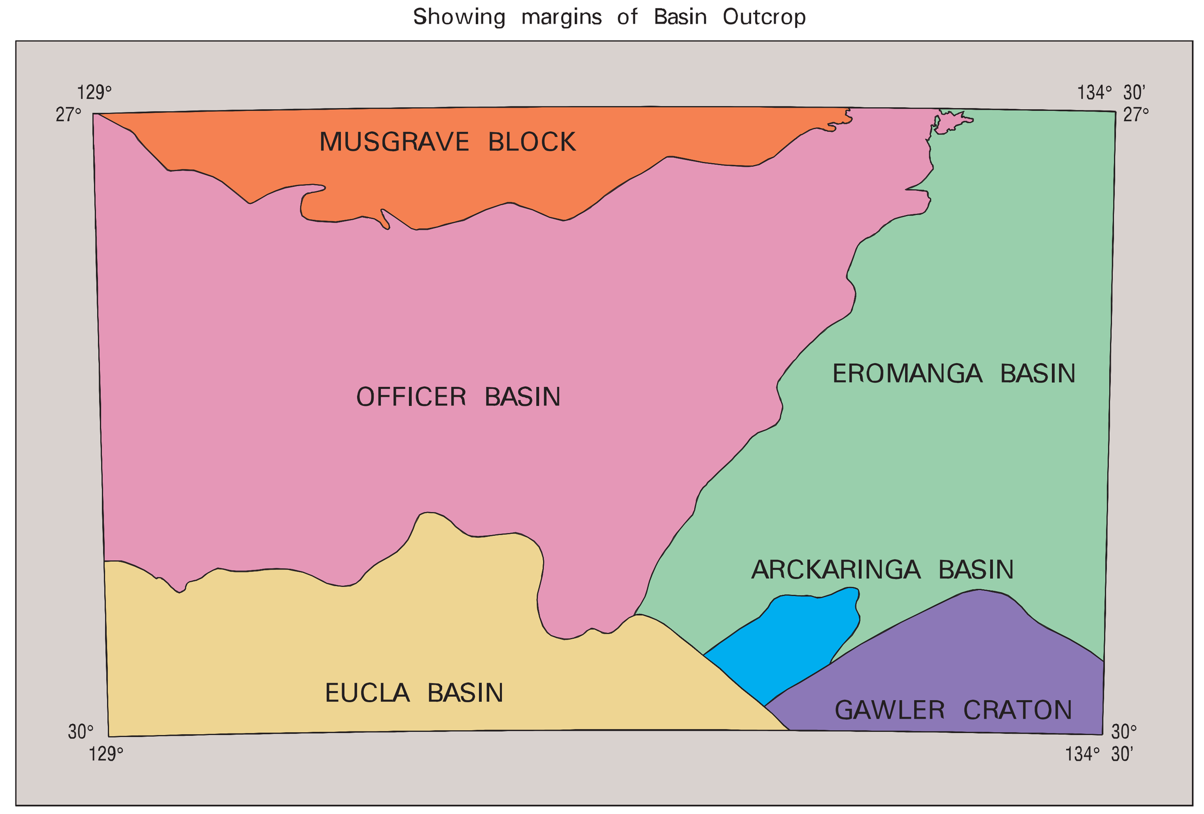
LOCALITY PLAN

GEOLOGICAL PROVINCES
Showing margins of Basin Outcrop



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Edited by D.Palfreyman, AGSO
Data collected by the Aeromagnetic Group, AGSO, and processed by C.Tarlowski
Cartography by A.J.Retter, AGSO
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In : Lindsay,J.F. (editor),Geological Atlas of the Officer Basin, South Australia. Australian Geological Survey Organisation, Canberra and Department of Mines and Energy South Australia

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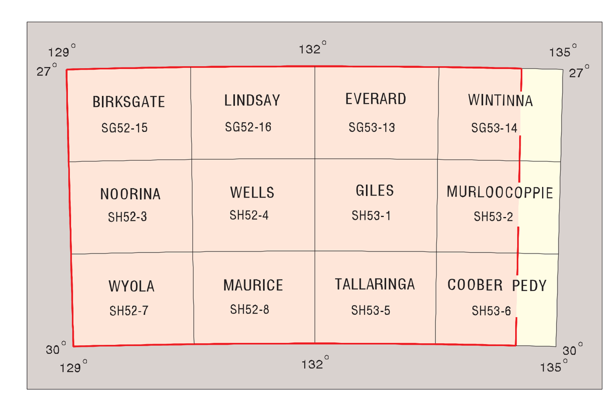

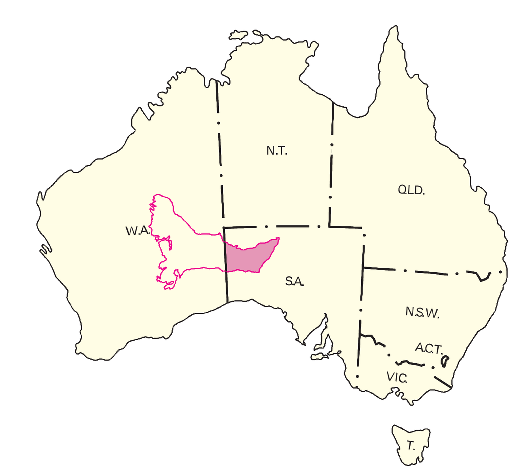

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GEOLOGICAL ATLAS OF THE OFFICER BASIN, SOUTH AUSTRALIA

PLATE 30
Total Magnetic Intensity Image
1995

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