# QUARTERLY GEOLOGICAL NOTES

Issued By

ISSN 0584–3219

THE GEOLOGICAL SURVEY OF SOUTH AUSTRALIA

Contents





JANUARY 1990 NUMBER 113

# The YARLE SANDSTONE: a Miocene coastal terrigenous sequence of the Eucla Platform [1]

*M.C. Benbow*

## INTRODUCTION

Terrigenous sedimentary rocks of Tertiary age occur along the northeastern margin of the Eucla Platform, adjacent to the inner, landward limit of the limestone-capped Nullarbor Plain (Fig. 1). These rocks are weathered, commonly capped by silcrete and ferricrete and are exposed in the vicinity of playa lakes. In the early studies by King (1950, 1951) they were divided into several informal lithostratigraphic units. Much of this stratigraphic record that was subsequently intersected in the extensive drilling of exploration companies and SADME is referred to as the Pidinga Formation and Hampton Sandstone. The latter formation is a terrestrial and marine sequence of Middle Eocene to possibly Early Oligocene age that was deposited around the margin of the platform and along the adjacent palaeochannels (Fig. 1; Harris, 1966; Lindsay and Harris, 1975; Kwitko, 1983; Alley and Benbow, 1989; Benbow, in prep.; Benbow *et al.*, in prep.).

An Early to Middle Miocene narrow coastal belt of mainly sand has now been identified and is named the Yarle Sandstone (Benbow, in prep.). This brief note provides a definition of this new lithostratigraphic unit. The names used by earlier workers for conceptually equivalent units in the northwestern and northern parts of the Eucla Platform have not been used (see below).

## DEFINITION

*Derivation of name:*

Yarle Lakes on the northeastern margin of the Nullarbor Plain, between Watson and Maralinga (Fig. 1).

*Distribution:*

The Yarle Sandstone occurs along the northeastern margin of the Nullarbor Plain, between Yarle Lakes and Seven Mile Swamps, adjacent to the Ooldea Range (Fig. 1; Benbow and Lindsay, 1988, fig. 1). It apparently forms a narrow belt, generally less than 10 km wide, along the inner margin of the Miocene platform, at the limit of the Nullarbor Limestone. There are exposures, now silicified and ferruginised, in the floors and around the margins of the playa lakes, and also along the adjacent interdune corridors on the margin of the Great Victoria Desert between Yarle Lakes and Ooldea.

*Type Area:*

This is located at Yarle Lakes; A type section has not been chosen because of minimal section exposure and uncertainty of recognition in drillholes that are commonly inadequately sampled.

---

1. This name amends and replaces the term Eucla Basin (Benbow, *et al.*, in prep; Benbow, in prep; James and Bone, in prep.)

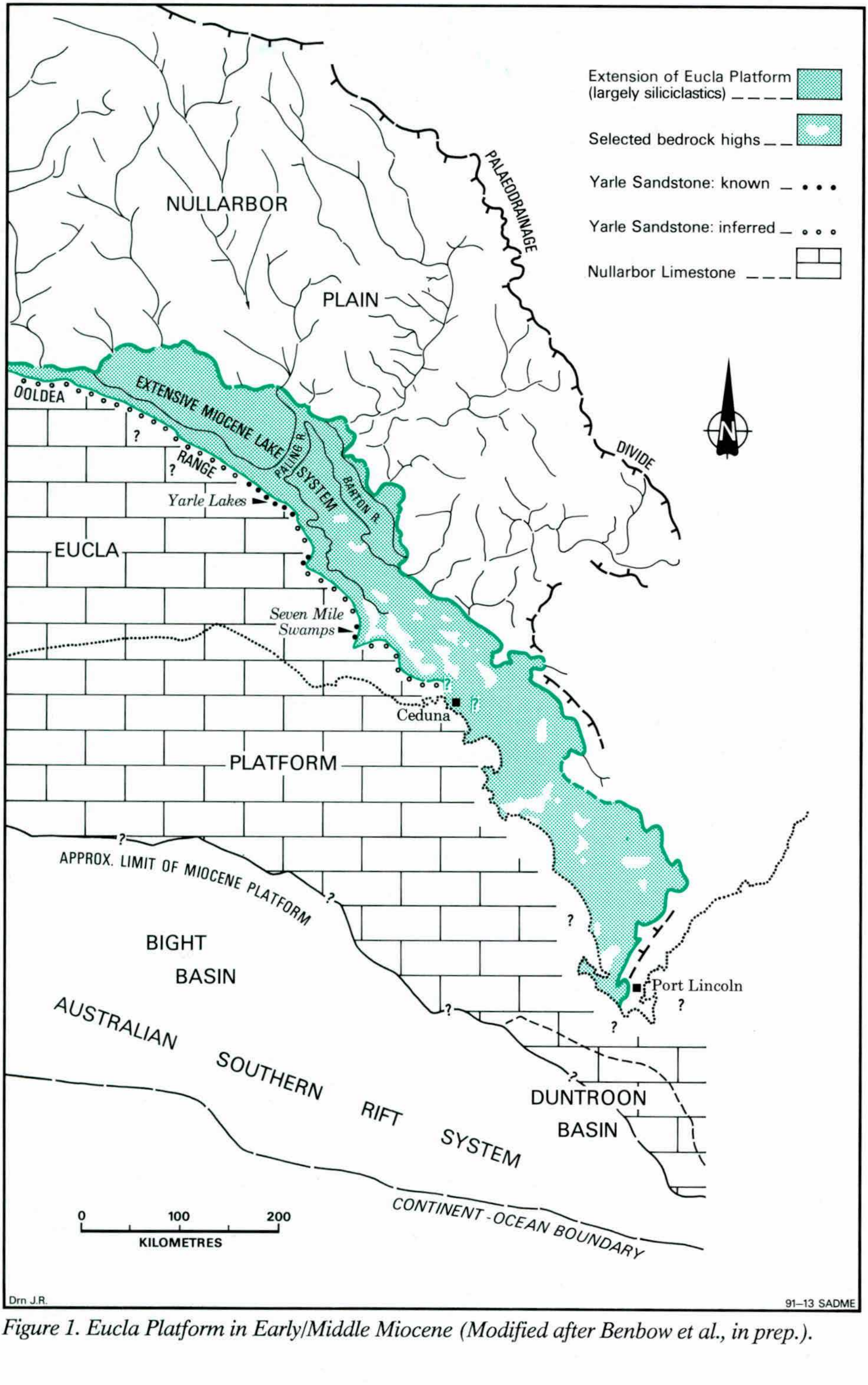


*Figure 1. Eucla Platform in Early/Middle Miocene (Modified after Benbow et al., in prep.).*

*Lithology:*

The formation is composed predominantly of quartz-rich sand, with a local bioclastic component that includes abraded fragments of foraminifers, echinoids, algae and molluscs. In the Yarle Lakes - Ooldea area the sand is mostly very fine to medium-grained. The finer sand is commonly bimodal, with a subsidiary mode of coarse to very coarse-grained, well rounded quartz. Here there are also rare deformed, irregularly shaped clasts of yellow-brown limestone similar to those which make up the Nullarbor Limestone. Minor terrigenous mud also occurs. At Yarle Lakes there is cross-bedding that dips shorewards to the northeast; this is partly destroyed by bioturbation.

*Thickness:*

Up to 5 m of section is exposed, but generally less than 2 m is evident. Maximum thickness could be about 20 m, if the sand, intersected in the nearby Maralinga 14 to 17 wells is assigned to the formation (Benbow, 1990, fig. 7).

*Relationships and boundary criteria:*

The formation unconformably overlies weathered Precambrian basement of the Gawler Craton and sedimentary rocks of the Neoproterozoic - Palaeozoic Officer Basin. At Seven Mile Swamps in Australian Mining Corporation (AMC) 316-5 drillhole where the unit is ~ 10 m thick and silcrete capped, the formation appears to conformably overlie very thin limestone that is at present included in the Nullarbor Limestone (Benbow and Lindsay, 1988). Here the basal sand is calcareous. In the type area, Yarle Sandstone is overlain sharply but apparently conformably, by foraminiferal packstone of the Nullarbor Limestone. Silicification and ferruginisation has obscured the nature of the boundary. The absence of a basal transgressive lag, seen elsewhere at the base of the Nullarbor Limestone, and the occurrence of limestone clasts, supports a conformable relationship. Conspicuous intertonguing of Yarle Sandstone and Nullarbor Limestone has not been observed and any intertonguing that may have existed is considered to have been largely removed by post-depositional erosion. Also in the Yarle Lakes region, the formation is unconformably overlain by Quaternary aeolian sand of the Great Victoria Desert. Where Yarle Sandstone is not duricrust capped, the position of the upper boundary is difficult to judge because of reworking and Quaternary weathering.

*Age:*

The presence of the large benthonic foraminifer *Austrotrillina howchini* and *Marginopora vertebralis* (the latter has been observed in the limestone clasts), indicates an age no older than earliest Miocene (Adams, 1984). An Early to early Middle Miocene age may be deduced from the age of the Nullarbor Limestone (Benbow and Lindsay, 1988 and references therein). Lindsay (*in:* Benbow and Lindsay, 1988) interprets an Early Miocene (Longfordian) age for the conformably underlying thin limestone at Seven Mile Swamps in AMC 316-5.

*Synonymy:*

The previously published names for conceptually equivalent rocks on the northwestern and northern part of the platform, the Colville Sandstone (Lowry, 1970) and Plumridge Beds (Lowry *et al.*, 1972; Jackson and van de Graaff, 1981) are not used (Benbow, in prep.). Examination of the type and reference sections of the former unit indicate that the limestone is best included within the Nullarbor Limestone and that the bulk (at least) of the terrigenous sediments are likely to be Cretaceous, if not Permian, in age. At one of the reference sections, basal and capping limestone units were described as being separated by about 20 m of shale, sandstone and conglomerate, however it appears that there is only one limestone unit. An unconformable relationship can be demonstrated between it and the underlying sandstone. There is a transgressive lag beneath this limestone, not described by Lowry (1970), as occurs around the east margin of the Eucla Platform.

The term Plumridge Beds is not used since a relationship with Nullarbor Limestone cannot be demonstrated and the lithological variation of this unit is much greater than that known for the Yarle Sandstone. Furthermore, estimated thicknesses of 20-100 m (Playford *et al.*, 1975; Jackson and van de Graaff, 1981) far exceed that known for the Yarle Sandstone.

## DISCUSSION

Lowry's (1970) interpretation of a wide (up to 120 km) inner platform belt of terrigenous dominated sediments for the Eucla Platform during the Early to Middle Miocene appears to be unfounded. It appears instead that such sediments were confined to a very narrow coastal zone as can be demonstrated around the eastern Eucla Platform. The minor terrigenous component of the Nullarbor Limestone, particularly at its landward limit, is consistent with this. Very little accession of sediment to the eastern platform via the peripheral palaeo-rivers is thus implied, reinforcing the earlier observations of Ludbrook (1958). The Ooldea Range was already in place by this time, but is likely to have undergone some reactivation during the Early to Middle Miocene transgression(s) (Benbow, 1990).

The sharp nature of the transition from the carbonates that extended over most of the Miocene platform to the siliciclastic sands of the platform margin is significant. The Yarle Sandstone was deposited in moderately energetic upper shoreface to foreshore environments of linear shorelines and embayments. Shorewards directed wave energy was not sufficient to carry a significant quantity of biogenically derived clasts from the subtidal carbonate of the Nullarbor Limestone that were deposited on the platform in deeper water further offshore. Longshore currents may have been effective in impeding shoreward transport of carbonate detritus. Basinwards slope of this incipiently drowned carbonate platform was negligible at this time.

*KEYWORDS: STRATIGRAPHIC DEFINITION/Type section/Miocene/Eucla Platform/Yarle Sandstone/Yarle Lakes/Ooldea SH 52-12.*

REFERENCES

Adams, C.G., 1984. Neogene larger foraminfera, evolutionary and geological events in the context of datum planes. *In:* Ikebe, N. and Tsuchi, R. (Eds), *Pacific Neogene datum planes*. Contributions to Biostratigraphy and Chronology. University of Tokyo Press, Tokyo, pp.47-67.

Alley, N.F. and Benbow, M.C., 1989. Late Eocene palynofloras from the Pidinga Formation, SADME Ooldea Range 6, eastern Eucla Basin. *South Australia. Geological Survey. Quarterly Geological Notes,* 111:2-12.

Benbow, M.C., 1990. Tertiary coastal dunes of the Eucla Basin, Australia. *Geomorphology*, 3:9-29.

Benbow, M.C., in prep. Tertiary stratigraphy of the Eastern Eucla Platform region. *University of Adelaide. Ph.D. thesis* (unpublished).

Benbow, M.C. and Lindsay, J.M., 1988. Discovery of *Lepidocyclina* (Foraminiferida) in the Eucla Basin. *South Australia. Geological Survey. Quarterly Geological Notes*, 107:2-8.

Benbow, M.C., Lindsay, J.M. and Alley, N.F., in prep. Bight and Duntroon Basins, Eucla Platform and Palaeodrainage. *In:* Johns, R.K. (Ed.), The geology of South Australia. *South Australia. Geological Survey.*

Harris, W.K., 1966. New and redefined names in South Australian Lower Tertiary stratigraphy. *South Australia. Geological Survey. Quarterly Geological Notes*, 20:1-3.

Jackson, M.J. and van de Graaff, W.J.E., 1981. Geology of the Officer Basin. *Bureau of Mineral Resources, Geology and Geophysics, Australia. Bulletin*, 206.

James, N.P. and Bone, Y., in prep. Sediment dynamics of a cool water Oligo-Miocene shelf limestone, Eucla Platform, southern Australia.

King, D., 1950. A geological investigation along the eastern margin of the Nullarbor Plain. *University of Adelaide. M.Sc. thesis* (unpublished).

King, D., 1951. The geology of the Pidinga area. *Royal Society of South Australia. Transactions*, 74:25-43.

Kwitko, G., 1983. Tertiary coals of the eastern Eucla Basin, South Australia. *Mineral Resources Review, South Australia,* 152:42-56.

Lindsay, J.M. and Harris, W.K., 1975. Fossiliferous marine and non-marine Cainozoic rocks from the eastern Eucla Basin, South Australia. *Mineral Resources Review, South Australia,* 138:29-42.

Lowry, D.C., 1970. Geology of the Western Australian part of the Eucla Basin. *Western Australia. Geological Survey. Bulletin,* 122.

Lowry, D.C., Jackson, M.J., van de Graaff, W.J.E. and Kennewell, P.J., 1972. Preliminary results of geological mapping in the Officer Basin, Western Australia, 1971. *Western Australia. Geological Survey. Annual Report,* 1971, pp.50-56.

Ludbrook, N.H., 1958. The Eucla Basin in South Australia. *In:* M.F. Glaessner and L.W. Parkin (Eds), The geology of South Australia. *Geological Society of Australia. Journal,* 5 (2):127-135.

Playford, P.E., Cope, R.N., Cockbain, A.E., Low, G.H. and Lowry, D.C., 1975. Phanerozoic (Chapter 2). *In:* The Geology of Western Australia. *Western Australia. Geological Survey. Memoir,* 2:410-419.

# LATE QUATERNARY STRATIGRAPHY of the Roonka archaeological sites

*P.A. Rogers*

## INTRODUCTION

The Roonka archaeological sites are adjacent to the Murray River between five and seven kilometres north of Blanchetown (Fig. 1); they are important because of evidence of long-term Aboriginal occupation. The area has been investigated since 1968 by Graeme Pretty of the South Australian Museum, and others.

Firman (1985), prepared a preliminary report on the Roonka sites. He also proposed 16 shallow auger holes, which were drilled by M. Flintoft and S. Ewens in 1984, to assist the SA Museum in its study of Roonka.

## GEOLOGICAL SETTING

Roonka is located near the western margin of the Cainozoic Murray Basin (Fig. 1), a roughly circular epicratonic basin, of about 300 000 km$^2$, containing up to 600 m of fresh-water, marine, marginal marine, and continental deposits of Paleocene to Quaternary age.

Some 30 km to the west are the Mount Lofty Ranges which comprise folded sedimentary rocks and minor volcanics of Late Proterozoic (Adelaidean) and Cambrian age, in places metamorphosed and intruded by Ordovician granite and other igneous rocks. Rocks similar to those of the Mount Lofty Ranges underlie the Murray Basin in the Roonka area.

Roonka is situated in a section of the Murray River which is incised in an extensive calcrete plain (Fig. 2). About seven kilometres west of the river, a linear escarpment about 35 m high, marks the position of the Morgan Fault. The height of the escarpment may reflect the magnitude of displacement of subsurface units. The Morgan Fault is the controlling structure on the markedly straight stretch of the Murray River between Morgan and Swan Reach (Fig. 1).

East of the river, the calcrete plain passes under a blanket of east-west trending linear dunes. Nearer the river, the calcrete surface is interrupted by irregular, parabolic, source-bordering dunes.

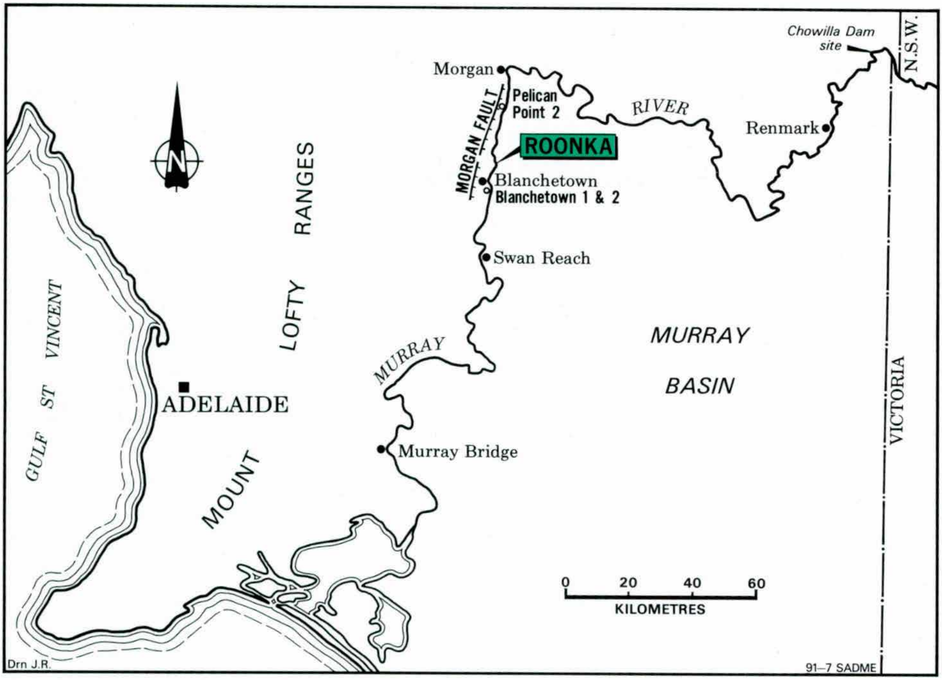


*Figure 1. Roonka, location plan*

## LATE QUATERNARY STRATIGRAPHY OF THE ROONKA SITES

*Fluvial deposits of the Murray River Valley*

Fluvial sediments which form the floor of the Murray River valley at Roonka can be divided into late Pleistocene upper terrace deposits and latest Pleistocene to Holocene Monoman and Coonambidgal Formations (Fig. 3). These successions consist of fining-upwards sediments deposited during post-glacial periods of rising sea level.

*Upper terrace deposits*

The upper terrace deposits which form Roonka Flat (Fig. 2), lie 2-4 m above the modern floodplain.

Drilling of the flat has allowed recognition of a three-part division of deposits. A fourth (basal) unit (Qpb) was not reached by the shallow holes, but is extrapolated from Blanchetown 2 where it occurs as a 1 m bed of medium to coarse-grained sand. The drillholes at Roonka bottomed in a lower fluvial unit ($Qpa_1$) of pale yellow-grey silt and very fine to fine-grained and minor medium-grained sand. Total thickness of the lower fluvial unit in Blanchetown 2 is 8 m, and is inferred to be up to 11 m at Roonka.

Overlying the lower fluvial unit is a lagoonal unit (Qpl), consisting of 2 to 3.5 m of silty and clayey very fine to fine-grained sand, and sandy clay. In outcrop, the clay-rich sediments are pedologically structured and mottled red-brown and grey, and contain nodular carbonate.

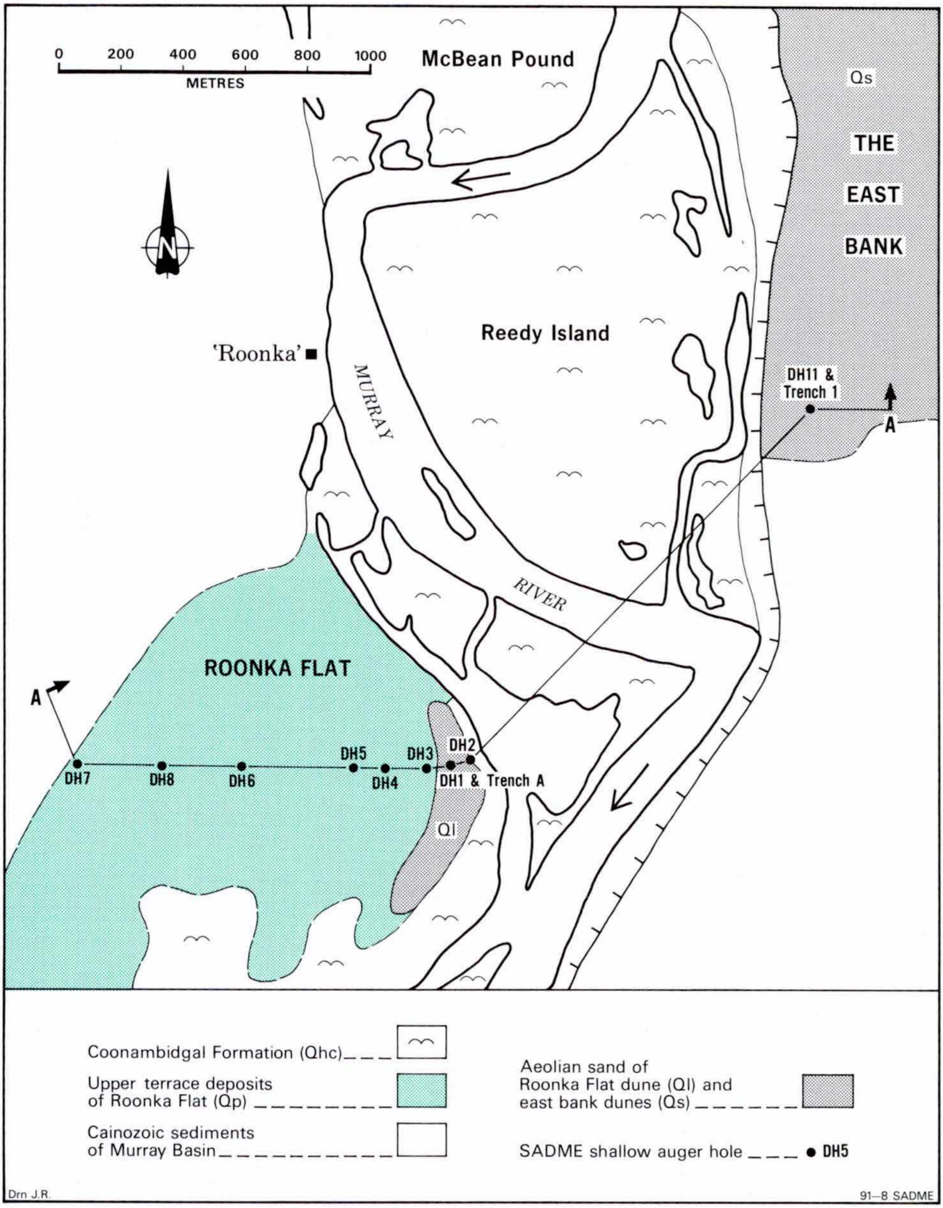


*Figure 2. Roonka, topographic and geological features*

The upper fluvial unit (Qpa2) at the western and eastern margins of Roonka Flat consists of pale to medium grey, silty very fine to medium-grained sand and is 1.4 to 4.85 m thick. The unit crops out between DH 4 and DH 5 (Fig. 2) as a grey mottled and pedologically structured clayey sand with nodular carbonate. The upper fluvial unit overlies and cuts into the lagoonal unit. It is interpreted as comprising channel and overbank deposits which may have formed during a major flood.

The palaeosol at the top of the upper terrace deposits (Fig. 4) which is characterised by mottling and structuring of clays and nodular pedogenic carbonate, has yielded thermoluminescence dates of 65 000 ± 12 000 yrs BP (Prescott, 1983) and about 60 000 yrs BP (J.T. Hutton*). These dates indicate that the upper terrace deposits at Roonka can be correlated with a period of rising sea level between 65 000 and 59 000 yrs BP, as seen in the recalculated sea level curve for Huon Peninsula in New Guinea (Chappell and Shackleton, 1986; Fig. 6).

The coarse grain size of the basal unit indicates a high flow rate suggesting that sea level, although rising, was still well below the modern datum. The lower and upper fluvial units, and the lagoonal unit, are similar in grain size to Holocene fluvial beds of the Coonambidgal Formation. They were probably deposited when the sea was nearer its present level.

The upper terrace succession at Roonka can be correlated with the Rufus Formation of Gill (1973). Similar deposits are recorded in the Chowilla area (Ludbrook, 1960; Rogers, 1978; Firman, 1973, fig. 22).

*Monoman and Coonambidgal Formations*

Following deposition of the upper terrace deposits, a short-lived drop in sea level caused the river to cut down through the late Pleistocene fluvial deposits, forming a new channel which was subsequently filled by a succession of latest Pleistocene to Holocene riverine sediments. Drilling at Blanchetown (Steel, 1959; Blanchetown 1) has shown that downcutting has occurred to a maximum depth of 15 m below Australian Height Datum (AHD).

* J. T. Hutton, Dept. of Physics, University of Adelaide, pers. comm., 1988.

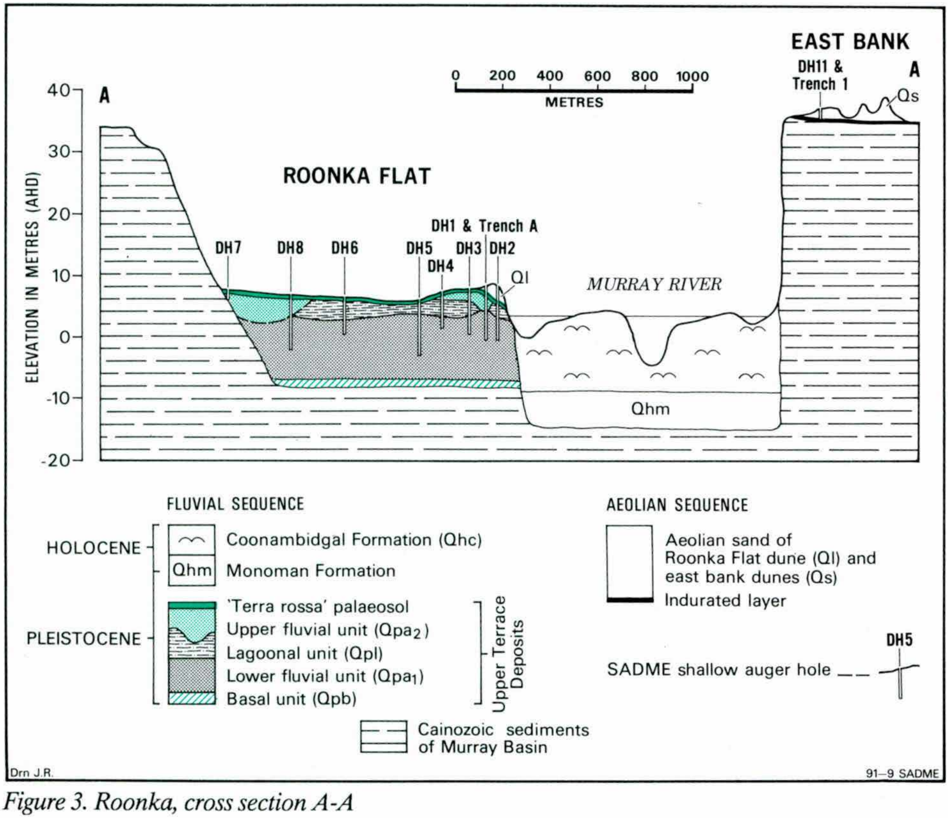


*Figure 3. Roonka, cross section A-A*

The younger fluvial succession of the Murray River in South Australia has been divided into two units: Monoman Formation and Coonambidgal Formation.

The older Monoman Formation (Firman, 1966; 1973) is 6 m thick in Blanchetown 1 and consists of medium to coarse-grained sand, with fine gravel at the base. At the Chowilla Dam site, a horizon of logs and stumps underlies oxidised coarse-grained sand and gravel and overlies similar sediments that are unoxidised. Radiocarbon dates of 7 200 ± 140 yr BP and 4 040 ± 100 yr BP have been obtained from the wood, with the younger age coming from the upper part of the wood horizon (Firman, 1971; Gill, 1973). Gill interpreted the wood horizon as a disconformity representing a time span of about 3 000 years. He suggested placing the boundary between the Monoman and Coonambidgal Formations at the wood horizon although, on lithological grounds, the oxidised coarse-grained sand and gravel overlying it could be included in the Monoman Formation. In Pelican Point 2, a similar wood horizon clearly overlies the coarser sediments, supporting the view that it marks a disconformable contact between the two formations.

Fossil vertebrate remains from the lower part of the Monoman Formation at Chowilla have been identified as *Phascolonus* c.f. *gigas* and *Macropus ferragus*, and may indicate a late Pleistocene age (Marshall, 1973).

The Monoman Formation is overlain by the Coonamabidgal Formation (Firman, 1973). This unit was defined originally by Lawrence (1966) to include all the fluvial deposits of the Murray Valley. In South Australia, the Coonambidgal Formation has been restricted to finer grained sediments overlying Monoman Formation in the younger succession of fluvial deposition.

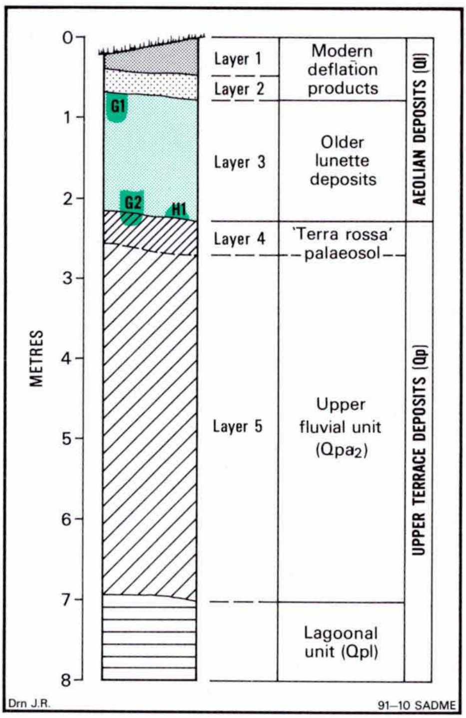


*Figure 4. Roonka , trench A stratigraphic column*

The Coonambidgal Formation is composed mainly of fine-grained sand and the fine sandy clay in drillholes at Blanchetown and Pelican Point. The unit is 13 m thick in Blanchetown 1 drillhole. The Coonambidgal Formation includes modern point bar, lagoonal and floodplain sediments.

The Monoman and Coonambidgal Formations were deposited following the last glacial maximum at about 18 000 yrs BP when sea level was at one of its lowest points (between 100 and 150 m below AHD). Downcutting by the Murray River during the sea level minimum extended to 15 m below AHD at Blanchetown (compared with –8 m at the 65 000 yrs BP sea level minimum) and to –65 m near Murray Bridge (Twidale *et al.*, 1978). At the end of the last glacial period sea level rose relatively rapidly, and reached its present position around the South Australian coast at about 7 000 yrs BP (Belperio *et al.*, 1983). The Monoman Formation was deposited during this period. As the sea approached its modern level, depositional surfaces in the Murray Valley stabilised and forests developed. The disconformable wood horizon at Chowilla represents a forest which grew over a period of about 3 000 years. Deposition of Coonambidgal Formation commenced between 7 000 yrs BP and 4 000 yrs BP and continues to the present day. The sea was at, or close to, its present level during this period.

*Aeolian deposits*

The dune sand beds at Roonka are the geological units of archaeological interest, as they contain graves, fireplaces, and other evidence of Aboriginal occupation. The aeolian deposits occur at two locations: the east bank and the eastern margin of Roonka Flat (Fig. 2). Both these occurrences are assigned to the Bunyip Sand (Firman, 1966), which comprises source bordering dunes in and adjacent to the Murray River valley.

*Roonka Flat dune*

The aeolian deposits (Ql) at the eastern margin of Roonka Flat form a low arcuate rise about 500 m long, and up to 1.5 m above the adjacent flat (Fig. 2). Drillhole samples consist of pale red-brown, well sorted and rounded, fine to coarse-grained quartz sand.

The aeolian sand disconformably overlies upper fluvial and lagoonal units of the upper terrace deposits. The disconformity is marked by a 'terra rossa' palaeosol recorded by Pretty (1977) at the top of the upper fluvial unit in Trench A. Furthermore, he divided the aeolian sequence exposed in Trench A into three layers (Fig. 4). Layers 1 and 2 consist of modern windblown deposits formed since the beginning of European settlement, while underlying layer 3 contains features of Aboriginal origin.

Bone from a grave in the upper part of layer 3 gave a radiocarbon date of 3 930 ± 120 yrs BP, and similar material from a grave in the lower part of layer 3 was dated at 6 910 ± 450 yrs BP. Charcoal from a hearth at the boundary between layers 3 and 4 yielded a date of 18 050 ± 340 yrs BP (Pretty, 1977). Further dating of various charcoal and bone samples from layer 3 (Polach and Pretty, in prep.) has produced a range of ages extending from modern (220 ± 80 yrs BP) to 12 200 ± 100 yrs BP. Preliminary thermoluminescence dates of 10 000 and 15 000 yrs BP have been obtained from layer 3 at depths of 0.45 m and 1.0 m respectively (J.T. Hutton*).

The Roonka Flat dune is interpreted as a lunette formed of material reworked by wind erosion from the adjacent alluvial flat. Radiocarbon and thermoluminescence dating indicate that aeolian deposition occurred during the period from about 18 000 yrs BP to the present. Initiation of lunette formation is associated with the last glacial maximum, when most of the lunettes and dunes of southern Australia were formed (Bowler, 1976).

*East bank south dune*

On the east bank of the Murray Valley, northeast of Roonka Flat (Fig. 2), is an extensive area of irregular low sand dunes with a linear east-west trend, bordered to the north and south by the calcrete surface which the dunes overlie. The southernmost of the dunes (Trench 1) was excavated and investigated in detail. The dunes are composed of pale brown, loose to weakly cohesive, fine to medium and fine to coarse-grained quartz sand with no obvious palaeosol development.

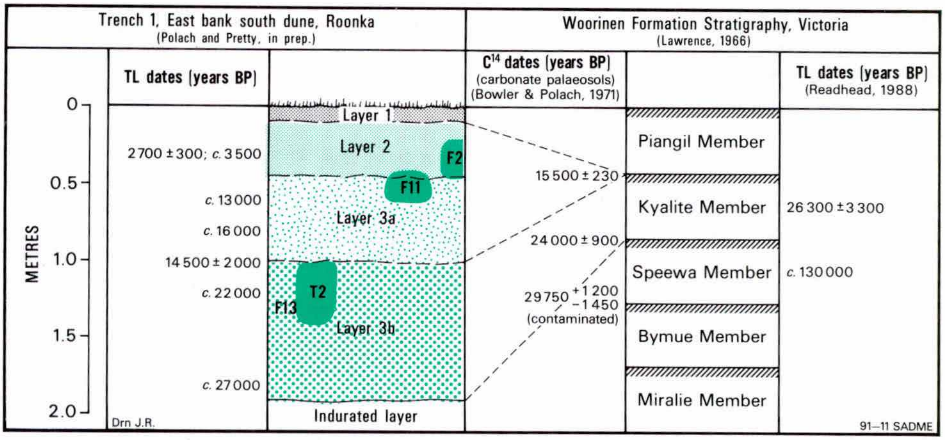


*Figure 5. Roonka, correlation diagram*

Polach and Pretty (in prep.) have divided the aeolian sequence (Qs) into three layers (Fig. 5). Layer 1 comprises modern windblown sand. Aboriginal fireplaces and graves occur in the underlying layers 2 and 3. Layer 3 has been further divided into two zones : an upper zone (3a) formed by ancient dune remobilisation; and a lower zone (3b) interpreted as an undisturbed remnant of the original dune core. The aeolian sequence rests on indurated red-brown sandy silt, which in turn overlies calcrete.

Calcrete fragments from a fireplace (F2) in layer 2 have yielded thermoluminescence dates of 960 ± 60 yrs BP and 1 070 ± 70 yrs BP. Radiocarbon dates of charcoal from the same fireplace have a wider range, from 360 ± 90 yrs BP to 1 110 ± 70 yrs BP (Prescott *et al.*, 1983). Thermoluminescence studies of a sand sample from a depth of 0.3 m in layer 2 have provided dates of 2 700 ± 300 yrs BP (Prescott, 1983) and 3 500 yrs BP (preliminary result from J.T. Hutton*).

Thermoluminescence dates ranging from 2 010 ± 150 to 2 450 ± 150 yrs BP have been obtained from a fireplace (F11) at the top of layer 3a. An anomalous radiocarbon date of 11 290 ± 1 570 yrs BP from the same source may be from ancient charcoal used in a younger fire (Prescott *et al.*, 1983). Preliminary thermoluminescence dates of sand samples at depths of 0.6 m and 0.8 m in layer 3a are 13 000 and 16 000 yrs BP respectively (J.T. Hutton*).

Layer 3b contains a fireplace (F13) which has yielded a radiocarbon date of 2 210 ± 130 yrs BP (Prescott *et al.*, 1983) and a grave (T2) with dates of 2 340 ± 330 and 6 680 ± 170 yrs BP (Polach and Pretty, in prep.). These dates are anomalously young, and probably reflect contamination of the samples. Prescott (1983) reports a thermoluminescence date of 14 500 ± 2 000 yrs BP from the top of layer 3b, and preliminary dates of 22 000 and 27 000 yrs BP have been obtained from depths of 1.2 and 1.8 m respectively (J.T. Hutton*).

A preliminary thermoluminescence date of 45 000 yrs BP was obtained from the indurated red-brown sandy silt that underlies the aeolian sequence (J.T. Hutton*). This layer may be equivalent to the 'terra rossa' palaeosol underlying the Roonka Flat dune.

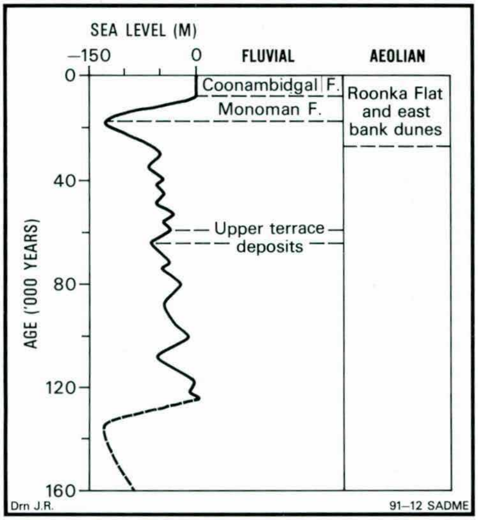


*Figure 6. Time/sea level graph*

Geochemical studies of the dune sand (Prescott and Hutton, in prep.). show variations in Ti/Zr and Al/Y ratios which support the field evidence for disconformable surfaces at 0.45 m (layer 2/3a boundary) and 1.0 m (layer 3a/3b boundary). Geochemical properties change abruptly at 1.9 m, at the top of the indurated layer which underlies the dune sequence.

The dates obtained from the east bank south dune have allowed a tentative time scale to be established for the aeolian sequence. Approximate maximum ages of 3 000, 15 000 and 27 000 yrs BP can be assigned to layers 2, 3a and 3b respectively. Layer 3b is a remnant of the original dune that formed between 27 000 and 15 000 yrs BP, during the last glacial maximum. The overlying layers represent periods of remobilisation that occurred between about 15 000 and 3 000 yrs BP (layer 3a), about 3 000 yrs BP (layer 2), and in the modern period (layer 3).

The east bank sequence at Roonka is correlated with the aeolian dune sequence of northwestern Victoria (Woorinen Formation; Lawrence, 1966) as indicated in figure 5. Thermoluminescence and radiocarbon dating indicate a close correlation between layer 3b and the Kyalite Member of the Woorinen Formation. Layer 1 at Roonka can be correlated with the Piangil Member (both consist of modern drift sand). However, the periods of aeolian reworking which formed layers 2 and 3a may not be represented in the Victorian sequence.

*KEYWORDS: SURFICIAL GEOLOGY/Fluvial sediments/River terraces/Aeolian sediments/ Dunes/Archaeology/Thermoluminescence dating/Carbon dating/Quaternary/Monoman Formation/Coonambidgal Formation/Bunyip Sand/Roonka archaeological site/Murray River/ SI 54-10: 6829-III.*

## REFERENCES

Belperio, A.P., Hails, J.R. and Gostin, V.A., 1983. A review of Holocene sea levels in South Australia. *In:* Australian sea levels in the last 15 000 years : a review. D. Hopley, (Ed.). *James Cook University of North Queensland. Department of Geography. Monograph Series. Occasional Paper*, 3:37-47.

Bowler, J.M., 1976. Aridity in Australia : Age, origins and expressions in aeolian landforms and sediments. *Earth Science Reviews*, 12:279.

Bowler, J.M. and Polach, H.A., 1971. Radiocarbon analysis of soil carbonates : an evaluation from paleosols in southeastern Australia. *In:* Yaalon, D.H. (Ed.), *Paleopedology: Origin, Nature and Dating of Paleosols*. International Society of Soils Science and Israel Universities Press, Jerusalem, pp.97-108.

Chappell, J. and Shackleton, N.J., 1986. Oxygen isotopes and sea level. *Nature*, 324:137-140.

Firman, J.B., 1966. Stratigraphy of the Chowilla area in the Murray Basin. *South Australia. Geological Survey. Quarterly Geological Notes,* 20:3-7.

Firman, J.B., 1971. Riverine and Swamp deposits in the Murray River tract, South Australia. *South Australia. Geological Survey. Quarterly Geological Notes*, 40:1-4.

Firman, J.B., 1973. Regional stratigraphy of surficial deposits in the Murray Basin and Gambier Embayment. *South Australia. Geological Survey. Report of Investigations*, 39.

Firman, J.B., 1985. Geological and geomorphological evolution of the Roonka area, South Australia. *South Australia. Department of Mines and Energy. Report Book*, 85/3.

Gill, E.D., 1973. Geology and Geomorphology of the Murray River region between Mildura and Renmark, Australia. *National Museum of Victoria. Memoirs*, 34:1-97.
Lawrence, C.R., 1966. Cainozoic stratigraphy and structure of the mallee region, Victoria. *Royal Society of Victoria. Proceedings*, 79:517-553.
Ludbrook, N.H., 1960. Chowilla dam site, River Murray. Stratigraphy and micropalaeontology. *South Australia. Department of Mines. Report Book*, 51/121.
Marshall, L.G., 1973. Fossil vertebrate faunas from the Lake Victoria region, S.W. New South Wales, Australia. *National Museum of Victoria. Memoirs*, 34:151-171.
Polach, H. and Pretty, G.L., in prep. Radiocarbon as an absolute dating tool at Roonka : Fulfilling the hopes and overcoming the limitations. *In:* Pretty, G.L. and Ward, G.G. (Eds), Territory, society and ideas in prehistoric Australia; results of the dating of Roonka in the lower Murray Basin, 1977-1986. *British Archaeological Reports (International Series).*
Prescott, J.R., 1983. TL dating of sands at Roonka, South Australia. *Pact*, 9:505-512.
Prescott, J.R. and Hutton, J.T., in prep. Thermoluminescence dating of Roonka sediments. *In:* Pretty, G.L. and Ward, G.G. (Eds), Territory, society and ideas in prehistoric Australia; results of the dating of Roonka in the lower Murray Basin, 1977-1986. *British Archaeological Reports (International Series).*
Prescott, J.R., Polach, H.A., Pretty, G.L. and Smith, B.W., 1983. Comparison of 14C and thermoluminescent dates from Roonka, South Australia. *Pact*, 8:205-211.
Pretty, G.L., 1977. The cultural chronology of the Roonka Flat, a preliminary consideration. *In:* Wright, R.V.S. (Ed.), Stone tools as cultural markers : Change, evolution and complexity. *Australian Institute of Aboriginal Studies, Canberra*, pp.288-331.
Readhead, M.L., 1988. Thermoluminescence dating study of quartz in aeolian sediments from southeastern Australia. *Quaternary Science Reviews*, 7:257-264.
Rogers, P.A., 1978. CHOWILLA, South Australia, Sheet SI54-6. *South Australia. Geological Survey. 1:250 000 Series - Explanatory Notes*.
Steel, R.D., 1959. Report on site investigation for proposed road bridge over the River Murray at Blanchetown. *South Australia. Department of Mines. Report Book*, 48/159.
Twidale, C.R., Lindsay, J.M. and Bourne, J.A., 1978. Age and origin of the Murray River and gorge in South Australia. *Royal Society of Victoria. Proceedings*, 90:27-42.

# The NORTHERN MARGIN of the WARBURTON BASIN

*L.R. Rankin and C.G. Gatehouse*

The intersection of crystalline basement and the Jurassic Hutton Sandstone, with no intervening Palaeozoic sediments in Haddon Downs 1, constrains the present northern margin of the Warburton Basin; it is further south than that interpreted by Gatehouse (1986). On geophysical evidence and proximity of outcropping Arunta Block metamorphics, this area of basement is interpreted as a southeastern extension of the Arunta Block.

## INTRODUCTION

The Warburton Basin (Wopfner, 1972) is a Cambrian-Devonian pericratonic basin bounded in the west by the Musgrave Block, in the south by the Muloorina Ridge and in the north by the Arunta Block (Gatehouse, 1986). The northern margin was previously interpreted as extending across the southern boundary of the Northern Territory and Queensland just north of Birdsville (Devine and Youngs, 1975; Gatehouse, 1986). Recent drilling in the northeast corner of South Australia at Santos Haddon Downs 1 did not intersect early Palaeozoic rocks, but passed from Jurassic Hutton Sandstone into crystalline basement (Rouse, 1987). The absence of early Palaeozoic sediments indicates that the present northern margin of the Warburton Basin is south of Santos Haddon Downs 1.

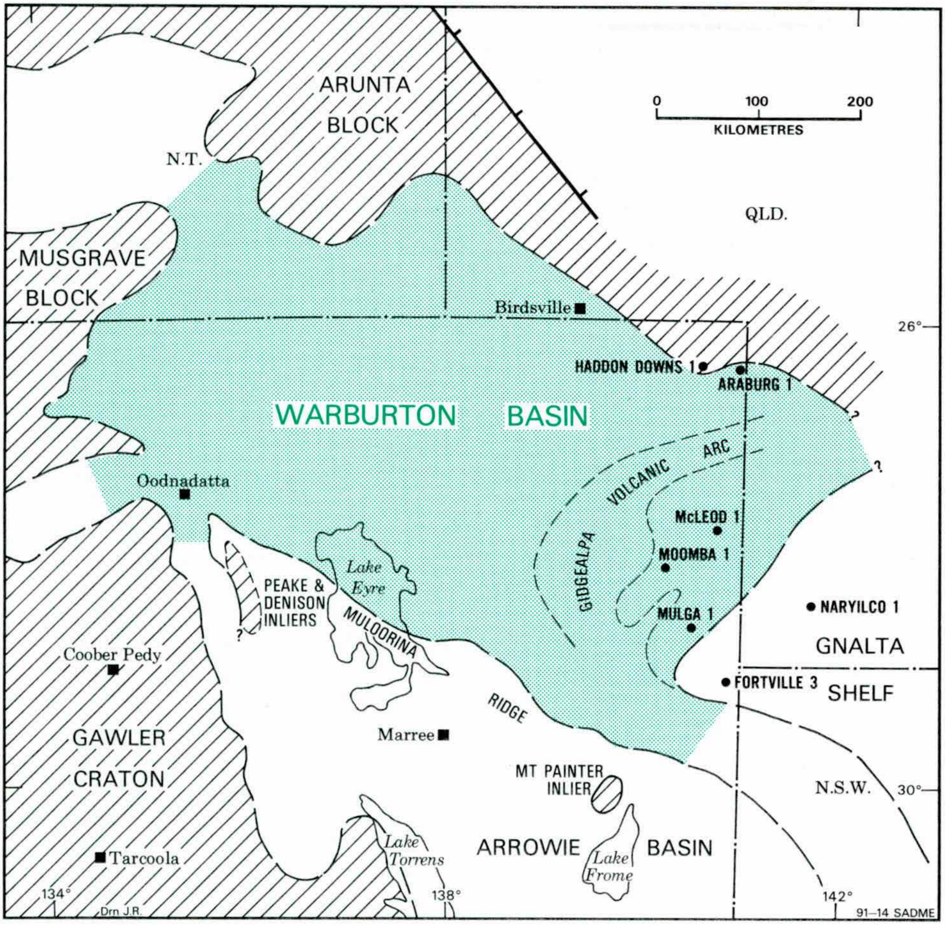


*Figure 1. Warburton Basin*

## GEOLOGY

Haddon Downs 1 was drilled to 2 007 m, intersecting 46 m of crystalline basement (of which 0.18 m was recovered as core). The core comprises protomylonitic pegmatitic gneiss. The gneiss has a moderate-intensity subvertical foliation defined by elongate quartz ribbons surrounding abundant coarse-grained, subhedral to anhedral K-feldspar and plagioclase megacrysts. Extensive ductile deformation and recrystallisation is evident in thin section (Appendix 1).

This gneiss is quite different in appearance from the typically undeformed Carboniferous granite, intersected in Delhi-Santos Moomba 1 and McLeod 1, which intrudes Warburton Basin sediments (Fanning, 1987). The gneiss is interpreted as basement to Warburton Basin sediments, rather than intrusive into them.

Crystalline basement was intersected in SADME Fortville 3 (Wopfner and Cornish, 1967) and was described as 'a highly sheared and folded, bounded quartz-sericite schist to phyllite, ... Quartz bands up to ½" thick are drag and reverse folded'. This lithology was interpreted as belonging to the Willyama Supergroup. Similar rocks intersected in Naryilco 1 and Mulga 1 are considered to be a northern extension of the Willyama Complex. This zone of shallow basement is known as the Gnalta Shelf (Scheibner, 1972; Webby, 1978; Gatehouse, 1986). No known Precambrian rocks have been intersected in drillholes between Naryilco 1 and Haddon Downs 1, a distance of 250 km.

## TECTONIC IMPLICATIONS

The lack of Cambrian-Devonian sediments in Haddon Downs 1 constrains the present northern margin of the Warburton Basin; on present evidence it must be further south than previously interpreted by Gatehouse (fig. 3, 1986). It is uncertain whether the basin margin is depositional, erosional, or faulted, although the presence of shallow shelf-facies sediments within Santos Araburg 1 (O'Neill, 1989) suggests that the area was at least a shallow marine platform, if not emergent, during early Palaeozoic sedimentation. The presence of fossils common to the Warburton and Georgina Basins supports the idea of a shallow marine connection in this area (Gatehouse, 1986). This shelf is a continuation of the Arunta Block; a zone of shallow basement southwest of, and implied as part of, the Arunta Inlier (Devine and Youngs, 1975; Gatehouse, 1986).

The basement in Haddon Downs 1 lies in a zone of west northwest-trending aeromagnetic fabric which was interpreted by Tucker *et al.* (1979) as a zone of metamorphics. This zone truncates the north-south trending fabric of the Mount Isa Block, and is roughly coincident with the aeromagnetics of the Arunta Block to the northwest. On this evidence the Haddon Downs area is interpreted as a continuation of the Arunta Block (the Arunta Platform, a palaeogeographic province marginal to the Warburton Basin).

Tentative extrapolation of the reinterpreted northern margin of the Warburton Basin suggests that the Gidgealpa Volcanic Arc may be terminated abruptly (perhaps by faulting) against the basement of the Arunta Platform in Queensland. The nature of the contact between the Arunta Block and the Willyama Block is obscured by Phanerozoic sediments and is unknown.

*KEYWORDS: REGIONAL GEOLOGY/Sedimentary basins/Basement/Gneiss/Arunta Block/ Warburton Basin/Haddon Downs 1/Cordillo SG 54-10: 7045.*

REFERENCES

Delhi Petroleum Pty Ltd, 1966. Moomba 1 well completion report. *South Australia. Department of Mines and Energy. Open file Envelope*, 631.

Devine, S.B. and Youngs, B.C., 1975. Review of the Palaeozoic stratigraphy and petroleum potential of northern South Australia. *APEA Journal*, 15:45-54.

Fanning, C.M., 1987. U-Pb zircon dating report. AMDEL report G 6103/84.

Gatehouse, C.G., 1986. The geology of the Warburton Basin in South Australia. *Australian Journal of Earth Sciences*, 33:161-180.

O'Neill, G.J., 1989. Araburg 1 well completion report. Compiled for SANTOS Ltd. *South Australia. Department of Mines and Energy. Closed file Envelope*.

Rouse, K.L., 1987. Haddon Downs 1 well completion report. Compiled for SANTOS Ltd. *South Australia. Department of Mines and Energy. Open file Envelope*, 7038/6.

Scheibner, E., 1972. The Kanmantoo pre-cratonic province in New South Wales. *New South Wales. Geological Survey. Quarterly Notes,* 7:1-10.

Tucker, D.H., Wyatt, B.W., Druce, E.C., Mathur, S.P. and Harrison, P.L., 1979. The upper crustal geology of the Georgina Basin region. *BMR Journal of Australian Geology and Geophysics*, 4:209-226.

Webby, B.D., 1978. History of the Ordovician continental platform shelf margin of Australia. *Geological Society of Australia. Journal,* 25:41-63.

Wopfner, H., 1972. Depositional history and tectonics of South Australian sedimentary basins. *South Australia. Mineral Resources Review*, 133:32-50.

Wopfner, H. and Cornish, B.E., 1967. S.A.G. Fortville 3 well completion report. *South Australia. Geological Survey. Report of Investigations*, 29.

## APPENDIX 1 - THIN SECTION DESCRIPTION

| | |
|---|---|
| Sample: | 7045 RS 23 |
| Thin Section: | TS C51402 |
| Lithology: | Protomylonitic pegmatite |
| Location: | Santos Haddon Downs 1 |
| Depth: | 2 012 m |

Hand Specimen: The drillcore sample is an orange-pink coarse-grained pegmatitic gneiss, with abundant coarse-grained subhedral to anhedral K-feldspar and plagioclase megacrysts surrounded by elongate quartz aggregate ribbons. The specimen has a moderate-intensity, subvertical foliation defined by the shape aspect of the quartz ribbons. No obvious stretching lineation was noted in the core.

Thin Section: Coarse-grained perthite and plagioclase occur within a framework of medium to coarse-grained quartz and minor recrystallised feldspar. The perthite grains are pervasively fractured, while plagioclase exhibits brittle fracturing, plastic lattice warping and recrystallisation to fine grains. Quartz is the most strained mineral within the specimen, with ductile deformations having produced ribbons of quartz exhibiting intense subgrain and deformation band boundary development, of new grains at grain and subgrain boundaries, and total recrystallisation of some grains to aggregates of very fine grains. The most-strained quartz grains occur adjacent to feldspar megacrysts. The quartz ribbons define a protomylonitic fabric.

The specimen has undergone tensile fracturing after the protomylonitic fabric formation, with development of calcite-filled veins at a high angle to the foliation.

Minor biotite within the specimen has been retrogressed and the feldspar grains have suffered minor sericitisation.

Modal Analysis:

| | |
|---|---|
| Perthite | 30% |
| Plagioclase | 30 |
| Quartz | 25 |
| Calcite | 8 |
| Sericite | 5 |
| Biotite | 2 |
| Zircon | trace |

Interpretation: The specimen is a quartz-rich pegmatite which has undergone moderate-intensity ductile deformation, producing a protomylonitic pegmatite gneiss.

# RECENT PUBLICATIONS

**Mines and Energy Review**

The Department of Mines and Energy is the Government organisation charged with administration of the mining, quarrying and petroleum industries, and with fostering exploration and development of mineral and water resources in SA. These activities have been recorded since 1905 in the Department's journal, known initially as the Review of Mining Operations in South Australia. The name changed to Mining Review, Adelaide in 1917, then to Mineral Resources Review, South Australia in 1969.

The title has now been changed to Mines and Energy Review, South Australia, commencing with issue No. 157. The changes in title, content and format reflect the need to promote a wider scope of development of mineral and energy resources, and report on geological and geophysical investigations in the State.

The journal will publicise the activities, operations and findings of not only SADME, but also those of other agencies and of the private sector, as appropriate. The price for No. 157 is $29.95.

No. 157: Main titles:

- Aggregate, sand and clay resources for metropolitan Adelaide (A.M. Pain and J.L. Keeling)
- Leigh Creek town water supply - a history (R.E. Read)
- Artificial recharge in the Angas-Bremer irrigation area (S.R. Howles)
- The Late Proterozoic Acraman Impact - towards an understanding of impact events in the sedimentary record (M.W. Wallace, G.E. Williams, V.A. Gostin and R.R. Keays)
- Magnetostratigraphic study of Late Adelaidean sediments in the eastern Officer Basin, South Australia (F.H. Chamalaun, C.C. von der Borch and C.G. Gatehouse)
- A guide to Quaternary volcanoes in the Lower South-East of South Australia (M.J. Sheard)
- Review of gold mineralisation in the Nackara Arc (B.J. Morris and C.M. Horn)
- Coongie Lakes Control Zone - a map and note for the surface geology and terrain (G.W. Krieg and R.A. Callen)
- Geophysical investigation - southwestern Great Artesian Basin (C.D. Cockshell)
- Stratigraphy and environments of deposition at Hallett Cove during the Late Palaeozoic (R.P. Bourman and N.F. Alley)

**CURNAMONA** Explanatory Notes - sheet SH 54-14 (R.A. Callen)

The notes and accompanying 1:250 000 geological map describe and interpret the geology of the Middle to Late Proterozoic Willyama Inliers and Benagerie Ridge, and younger cover sediments. The Willyama Inliers on CURNAMONA are of similar age and lithology to rocks at Broken Hill. Drilling on Benagerie Ridge has disclosed anomalous contents of copper, cobalt, gold, molybdenum and silver.

Eocene palaeochannels contain anomalous amounts of uranium, and several significant (otherwise economic) deposits including Honeymoon and Yarramba have been outlined by drilling.

Lake Pinpa on CURNAMONA is a Miocene version of the famous Lake Callabonna vertebrate fossil occurrence.

The Explanatory Notes and included map are available from SADME for $20.

*191 Greenhill Road,*
*Parkside,*
*South Australia 5063*

Prepared by the Publication Drafting Section
S.A. Department of Mines and Energy
Printed in Australia A.B.Caudell, Director and Government Printer, South Australia