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ASPECTS OF STRATIGRAPHY AND STRUCTURE IN RELATION TO THE WOOLPUNDA GROUNDWATER INTERCEPTION SCHEME, MURRAY BASIN, SOUTH AUSTRALIA

by

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ABSTRACT

An east-west cross-section has been constructed through the Murray Basin in the vicinity of the proposed Woolpunda Groundwater Interception Scheme. Structure is recognised by tracing several stratigraphic marker beds, including the Lepidocyclina foraminiferal zone and the three clay or marl units of known or potential hydrogeological significnace. Intermittent mild Cainozoic uplift and east-west arching are evident and appear to relate to draping over an underlying high of Cretaceous rocks. East of Overland Corner there is monoclinal flexure down to the east over the deep-seated Hamley Fault, the Renmark Trough, and an extension of the Murrayville Monocline. Contours of the top of the Renmark (+ Buccleuch) Group (the confined aquifer) show an elongated zone of elevated structure centred on the W.G.I.S. area and aligned slightly east of north. The geological structure has a significant influence in promoting groundwater discharge to the Murray River in this area.

INTRODUCTION

The Woolpunda Groundwater Interception Scheme is being designed to minimise saline groundwater inflows to the Murray River in the critical stretch between Overland Corner and Waikerie (Figs 1, 2). As it happens, the area is also one of long-standing geological and biostratigraphic interest. Because an understanding of stratigraphy and structure is basic to such a project, we are taking this opportunity to update the published information on the area by means of comments on an east-west cross-section (Fig. 3) and a structure contour diagram for the top of the Renmark Group (or overlying Buccleuch Group, where present) (Fig. 4).

Telfer (1987, 1988) has recently outlined aspects of the Woolpunda Groundwater Interception Scheme. Groundwater flow lines of the Renmark (plus Buccleuch) Group confined aquifer coverge on the Waikerie-Overland Corner area from the east and north. Marls of the overlying Ettrick Formation act as an aquitard. Asymmetric mild anticlinal folding and draping of the sequence over resurgent structures in pre-Tertiary strata, together with the observed head difference between the aquifers, appear to encourage convergent groundwater flow to the area, and upward leakage of saline groundwater from the deep confined aquifer into the unconfined Murray Group aquifer, and hence into the Murray River.

STRATIGRAPHY AND STRUCTURE

A regional Cainozoic stratigraphic summary was compiled by Brown (1983).

Table 1 lists Tertiary units relevant to the area under discussion.

Table 1. Stratigraphy of Paleocene to Middle Miocene rock units of the western Murray Basin, S.A.

Age	Formation	Group
Middle Miocene Early M. Miocene	Pata Limestone Morgan Limestone (including Cadell Marl Lens and equivalents)	Murray Group
Early Miocene. Early Miocene (to latest Oligocene?).	Finniss Clay Mannum Formation	
Earliest Miocene to Late Oligocene.	(Gambier Limestone) Ettrick Formation	Glenelg Group
Oligocene(?) to Late Eocene.	Informal units	Buccleuch Group
Oligocene(?)-Eocene-Paleocene.	Olney Formation Warina Sand	Renmark Group

The cross-section is vertically exaggerated by a factor of 250. This large expansion is needed to distinguish the various units, especially in the Murray Group, but it grossly distorts angles of dip. The steepest dip on the cross-section (immediately east of Overland Corner) is only one degree 18 minutes at natural scale. The next steepest (between Lowbank and Waikerie) is only 13 minutes. At natural scale the total vertical dimension of the cross-section would only be one millimetre. However, most of the units shown, although only thin laminae at natural scale, display continuity across the area, and the correlations that are made relate to a consistent succession of litho- and bio-stratigraphy.

Gentle east-west arching of the Murray Group, the Ettrick Formation, and the Renmark Group (plus Buccleuch Group where present) is evident between Sunlands and Overland Corner. This was indicated by tracing the Lepidocyclina foraminiferal marker zone, developed within lower Morgan Limestone (Lindsay and Giles, 1973). The relatively large, extinct, benthonic foraminifer Lepidocyclina howchini Chapman and Crespin, with "tropical" affinities, characterises a thin zone dated early Middle Miocene, below the Cadell Marl Lens equivalent and above the Finniss Clay equivalent. The zone is only a few metres thick, represents a regional warm watermass/climatic episode of limited duration, occurs in a consistent stratigraphic position, and has been of great value in correlating sections of the Murray Group in outcrop and subsurface. In the Sunlands synclinal structure, the top of the zone is depressed more than 12 m below normal pool level, while in contrast it is elevated to nearly 33 m above the same datum at the Woolpunda Pumping Station valley section. The horizon provides an accurate indication of the 50-metre displacement of the Murray Group in the vicinity of Overland Corner.

This broadly arched structure has been confirmed by subsequent drilling (Barnett, 1984, 1988), for example WGIS wells 6929-427 and 6929-465. East of Overland Corner, tracing of rock units and the Lepidocyclina zone subsurface shows steeper dips down to the east. This is no doubt related to the deep-seated Hamley Fault and adjacent Renmark Trough, which trend northeast-southwest, and also probably to an extension of the Murrayville Monocline trending northwest-southeast (Fig. 2; see O'Driscoll, 1960, pp. 22-23; Lindsay & Bonnett, 1973; Firman, 1973, fig. 4; and Thornton, 1974, fig. 5). No faults are shown on Figure 3 since the very low natural dips do not seem to require fault displacements between correlation points and gentle flexure appears sufficient. Thornton (1974, fig. 10) indicated that fault displacement on the Hamley Fault did not extend up above Cretaceous units. Other lineaments, as portrayed for example by Firman (1970) and Lindsay & Giles (1973), have not yet been observed to produce faulting in the outcrop areas traversed by the cross-section.

In accord with structure in the Murray Group, contours of top Renmark Group (or Buccleuch Group where present) for this area show a central elongated zone of elevated structure above - 100 m AHD, aligned slightly east of north (Fig. 4). Contours fall away particularly to the east of this rise, affected apparently by the Hamley Fault/Monocline, the Renmark Trough, and an extension of the Murrayville Monocline.

Control for thickness and base of the Renmark (+ Buccleuch) Group is sparse for the line traversed by this cross-section, but available data agree with the structure outlined above. Only Beach Petroleum Monash-1 well, at the eastern end over the Renmark Trough, penetrated Renmark Group - with a thickness of at least 290 m - entering Cretaceous strata at a depth of 536 m (about -500 m AHD) (Ludbrook, 1965). Waikerie 28W well (6829-579), towards the western end, bottomed at 332 m (about -300 m AHD) in palynologically dated Middle Paleocene Renmark Group (Harris, in Lindsay & Bonnett, 1973, p. 22) which was considered to be probably near the bottom of the local Cainozoic sequence. Renmark (+ Buccleuch) Group in this well was at least 180 m thick. International Mining Overland Corner-1 well, situated 10 km north of the section line and to the west of the Hamley Fault (Fig. 2) is reported to have encountered Cretaceous strata at a depth of only 257 m (-188 m AHD): Renmark (+ any possible Buccleuch) Group was only 111 m thick (in Furr, 1984: data released with the permission of International Mining N.L.). This relatively shallow and thin intersection, supported by recent seismic data, suggests that Renmark (+ Buccleuch) Group is thinned and anticlinally draped over a high of pre-Tertiary rocks centred west of the Hamley Fault. Dips are steeper to the east, over the Hamley Fault: available information indicates that the vertical difference between the Cretaceous intersections in Overland Corner and Monash wells is 312 m. This is essentially the configuration shown by Telfer (1987, fig. 12, after Barnett).

The upwarping and thinning of Tertiary units over a ridge of pre-Tertiary "basement" rocks associated with the Hamley Fault has contributed to significant upward leakage from the Renmark (+ Buccleuch) Group confined aquifer to the overlying water table aquifer in the Murray Group which then discharges to the Murray River. Elsewhere in the Murray Basin, the driving force for groundwater discharge can also be related to high pressures and upward leakage created at permeability barriers formed where the aquifers are truncated by facies changes or significantly thinned by concealed basement barriers (Evans & Kellett, 1988).

East of Overland Corner, Pata Limestone is usually encountered as in Parcoola well 6929-351. However, west of Overland Corner the formation has mostly been removed by erosion during mild regional warping in the Middle to Late Miocene. A remnant of Pata Limestone, with a characteristic foraminiferal microfauna, is preserved subsurface in a synclinal keel in the vicinity of Waikerie well 28W (6829-579) (Lindsay and Bonnett, 1973). A more complete section of the formation, 13.4m thick, is preserved in a similar synclinal setting at the top of the Murray Group in

Ramco Heights No. 1 well (6829-451) (Lindsay, 1965). The same structure is probably responsible for the only known outcrop of Pata Limestone, at Sunlands Pumping Station (Fig. 2).It is evident that the Murray Group was gently folded prior to the erosional unconformity, of latest Miocene or earliest Pliocene age, which truncates it. The unconformity surface itself (base Bookpurnong Formation or Loxton Sands) is also slightly arched, suggesting subsequent deformation. The broadly domed land surface, discernible despite the exaggerated topography, suggests that such intermittent movement has continued to relatively recent times. Resurgent tectonics, the effects on overlying sedimentary sequences of the periodic activity of deep seated faults and flexures, have been noted previously in the Murray Basin (Twidale et al., 1978, p. 30). Incision of the Murray River gorge has kept pace with any uplift.

CLAY AND MARL UNITS

Correlatives of the Cadell Marl Lens (early Middle Miocene) are recognised within Morgan Limestone at several localities, with a major development in the Sunlands-Waikerie area. This is the "blue clay" unit noted by Barnes (1951) and, as observed by him and seen at Waikerie Pumping Station, it weathers to a sloping surface in contrast to the vertical cliffs of limestone or sandstone. The sloping shelf of damp marl is a prominent feature along the river cliffs near Waikerie, where it is associated with seepages, slumps, and hydrophytic vegetation. The Cadell Marl equivalent is at the eroded, local top of Morgan Limestone in Sunlands well 6829-351, and at cliff sections at "Longcliff" and at Overland Corner. The lenticular habit of the member is evident, but the Sunlands-Waikerie-Holder body, which extends at least 17 km east-west and is up to 22 m thick, comprises a substantial proportion of the Morgan Limestone in this area compared with the type section 5 km south of Morgan where the Cadell Marl Lens is only 91 m long (north-south) and up to 6.7 m thick (Ludbrook, 1961). Southeast of Overland Corner, in Parcoola well 6929-351, the Cadell Marl equivalent - logged as "grey fossiliferous sticky clay" - is prominent between 18 and 36 m depth in the Morgan Limestone section. Where correlatives are well developed they act as aquitards and have a significant influence on the hydrogeological properties of the upper Murray Group.

Finniss Clay equivalent comprises a fine-grained, clayey and silty intercalation within the limestones of the Murray Group, distinct from the Cadell Marl equivalent and generally found in this area a few metres below the Lepidocyclina zone at about the stratigraphic level of the Finniss Clay at its type section. The type section, at Mannum Pumping Station (Ludbrook, 1961, p. 46),

disconformably overlies echinoid-rich sandstones and limestones of stratotype Mannum Formation and passes upwards conformably by interbedding into a erosional remnant of Morgan Limestone. The main, basal, bed of the Finniss Clay is 1.8 m thick. The top of this bed is 3.3 m below the Lepidocyclina zone of which only the lowest part is preserved below the erosional surface (Lindsay and Giles, 1973).

In the Hugo Loffler Cave Cliff Reserve section, Finniss Clay equivalent is a soft silty marl with minor limestone, eroding more readily than the limestones above and below: the 4-metre high cave, after which "Cave Cliff" is named, is weathered out of the unit. At the Lowbank, "Longcliff", Woolpunda valley, and Overland Corner sections, similar softer and fine-grained intercalations at the same stratigraphic level weather to more gentle slopes than the surrounding limestones (compare Ludbrook, 1961, fig. 16). Both the Cadell Marl and the Finniss Clay equivalents can be recognised as slope-forming units at separate stratigraphic levels at "Longcliff" and Overland Corner. Lindsay and Bonnett (1973, p. 14) noted that in wells drilled at Waikerie, Finniss Clay equivalent comprises brownish-grey, soft, quartzose, fossiliferous silty marl with subordinate bryozoal limestone. Similar lithologies are encountered in wells at other localities. The unit does not develop to as great a thickness as the Cadell Marl equivalent, but seems to be more persistent. Hydrogeologically it would also be an aquitard, interrupting, perhaps significantly in places, the uniformity of Murray Group limestones.

Fossiliferous glauconitic marls of the Ettrick Formation comprise a distinctive unit within the succession, and form a significant aquitard. Marl lithology was the original distinguishing feature of the formation (Ludbrook, 1957), and the top of this lithology is a useful marker horizon although transitional at some localities. A generally concordant relationship to marker units in the Murray Group is apparent in Figure 3. Limestone at the top of Ettrick Formation forms part of the upper aquifer, and although microfaunally characteristic, may be difficult to distinguish lithologically from Mannum Formation limestone or a widespread tongue of Gambier Limestone (Ludbrook, 1969; Lindsay & Williams, 1977).

BUCCLEUCH GROUP

In Waikerie wells 6829-578,579, an interval 66 m thick correlated broadly with the Buccleuch Group intervenes between Ettrick Formation and Renmark Group (Lindsay and Bonnett, 1973). In particular, the lowest part, 10.7 m thick, compares both lithologically and microfaunally

with the lower part of the subsurface type section of Buccleuch Bed "A" described by Ludbrook (1961). In Monash-1 well, the interval comprising brown glauconitic sandy limestone with pyrite-quartz aggregates, and at the base, carbonised wood fragments (226-247 m), and about which there was some doubt as to correlation (Ludbrook, 1965), is here correlated tentatively with Buccleuch Group. At 247 m, taken to be top Renmark Group, the well passed into carbonaceous pyritic quartz sand, and at 253 m into earthy lignite. In contrast, the recently drilled Woolpunda well 6929-465 passed directly from Ettrick Formation marl into brittle lignite, comprising the top of Renmark Group, at depth 146 m. Further work is needed to trace the extent of the Buccleuch marine incursions into the Murray Basin, and to relate this to marginal-marine influence in Olney Formation, but hydrogeologically, the confined aquifer in the western Murray Basin comprises various units beneath the Ettrick Formation marl aquitard (Fig. 4).

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CAPTIONS FOR FIGURES

Figure 1. Locality map, western Murray Basin, South Australia.

Figure 2. Locality map for east-west cross-section, Monash-Sunlands, Woolpunda Groundwater Interception Scheme, western Murray Basin, S.A.

Figure 3. East-west cross-section, Monash-Sunlands, showing correlations and structure in mid-Tertiary succession (prepared by JML).

Figure 4. Contours of top of Renmark Group(or Buccleuch Group, if present), central western Murray Basin, S.A. (prepared by SRB).