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The Norwest Bend Formation: Implications for the evolution of Neogene drainage in southeastern Australia

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Abstract

Strontium isotope data indicate that sediments of the Norwest Bend Formation were deposited within a large estuarine system during the Latest Miocene to Early Pliocene (probably > 5 Ma). The Norwest Bend Formation is divisible into two members; a lower sand-dominated member and an upper oyster coquina member. These two units are separated by an irregular, erosion surface that has no correlative within the adjacent Loxton–Parilla Sands. Tectonism in the western Murray Basin adjacent to the Adelaide Foldbelt has exerted a considerable control over the formation of these estuarine sediments. The Lower Norwest Bend Formation occupies a paleodrainage system that was restricted to a region west of the Hamley Fault and was presumably incised following uplift of this western block. Flooding of this paleodrainage system produced the Lower Norwest Bend estuarine system. Later tectonism on the Hamley Fault resulted in the formation of the erosion surface within the Norwest Bend Formation. We suggest that the Norwest Bend estuarine system owes its existence to marginal tectonism associated with the young uplift of the Mt. Lofty-Flinders Ranges. The paleodrainage system incised prior to deposition of the Norwest Bend Formation differs markedly in geometry from the present Murray River-gorge system. This suggests that the modern Murray River system developed after deposition of the Late Miocene–Pliocene Norwest Bend Formation.

Keywords: Neogene; Sedimentation; Stratigraphy; Neotectonics; Norwest Bend Formation; Murray Basin

1. Introduction

As a consequence of its intraplate setting, Australia has previously been thought of as a largely stable continental landmass, where slow geomorphologic change has preserved ancient landforms (e.g. Twidale, 1998). Recent work however, has begun to challenge this notion suggesting that significant uplift (in excess of 200m) occurred across southern Australia during the Late Neogene (Dickinson et al., 2001, 2002; Wallace et al., 2005). This Late Neogene tectonism has had a profound effect on the sedimentary record of southeastern Australian basins that has largely been unrecognised until recently.

The Murray Basin in southeastern Australia has often been thought of as a basin that is largely unaffected by tectonism and preserves a near-perfect record of Late Neogene eustasy (Bowler, 1982; Kotsonis, 1995). The modern Murray River represents the basin's largest drainage system and the apparent tectonic stability of the region has led researchers to suggest that the Murray River system has occupied the same position since Pliocene times (Firman, 1965, 1973; Twidale et al., 1978; Stephenson, 1986; Stephenson and Brown, 1989; Pufahl et al., 2004). A Pliocene estuarine oyster-rich unit known as the Norwest Bend Formation outcrops along the Murray River and the presence of this paleoestuary has reinforced the concept of a long-lived Murray River with a history stretching back to the Pliocene (Firman, 1965, 1973; Twidale et al., 1978; Stephenson, 1986).

This report examines these oyster-rich sediments, and its relationship to Pliocene paleodrainage in the western Murray Basin. The estuarine nature of these sediments has previously hindered reliable age determinations due to a lack of bio-stratigraphic zonal indicators. Determining the stratigraphic relationship of the Norwest Bend Formation to surrounding Neogene units like the Loxton–Parilla Sands has also proven problematic (Ludbrook, 1961; Brown and Stephenson, 1991; Pufahl et al., 2004). Here we provide improved age constraints

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for the Norwest Bend Formation (via strontium isotope stratigraphy) and demonstrate the role that local tectonics has played in controlling the position of Neogene paleodrainage.

2. Geological setting

The Murray Basin is one of Australia's largest sedimentary basins and is host to important mineral sands and groundwater resources. Located in the southeast of the continent, it occupies parts of South Australia, New South Wales and Victoria (Fig. 1), and underlies the southwestern portion of the Murray–Darling catchment, covering an approximate area of 300,000 km^2. The basin is flanked by subdued mountain ranges of the Lachlan Fold Belt to the east and south, the Kanmantoo and Adelaide Fold Belts to the west, and the Broken Hill and Willyama Proterozoic basement blocks on the northwest.

The last major depositional cycle in the Murray Basin occurred during the middle Late Miocene to Pliocene. A large, regional Miocene–Pliocene unconformity separates Late Oligocene–Middle Miocene limestones (Murray Group Limestones) from Pliocene sediments (including the Bookpurnong Beds, the Loxton–Parilla Sands and the Norwest Bend Formation) (Brown and Stephenson, 1991). This unconformity is evident throughout all SE Australian basins and is thought to represent an intense period of Neogene tectonic activity beginning approximately at 10 Ma (Dickinson et al., 2001).

The Norwest Bend Formation is an oyster-rich unit that only occurs in the far western parts of the Murray Basin. The unit is generally considered to be of Pliocene age, with Cotton (1951) initially suggesting Early Pliocene deposition, while Ludbrook (1959, 1961) considered this to have occurred during the Late Pliocene. The oyster shells that dominate the Norwest Bend Formation are largely a single species, *Ostrea sturtiana* (Tate, 1885; Ludbrook, 1959; Ludbrook, 1961), and form extensive banks observed within the cliff-tops along the Murray River gorge, especially near the South Australian town of Morgan. The occurrence of these oyster beds was first formally described by Tate (1885) who measured a section at 'North-West-Bend Head Station', near Cadell. Subsequently the name of the unit was formalised into the 'Norwest Bend Formation' (Ludbrook, 1957, 1961).

The stratigraphic and paleoenvironmental relationship between the Norwest Bend Formation and the more extensive Loxton–Parilla Sands remains unresolved (Fig. 2). In South

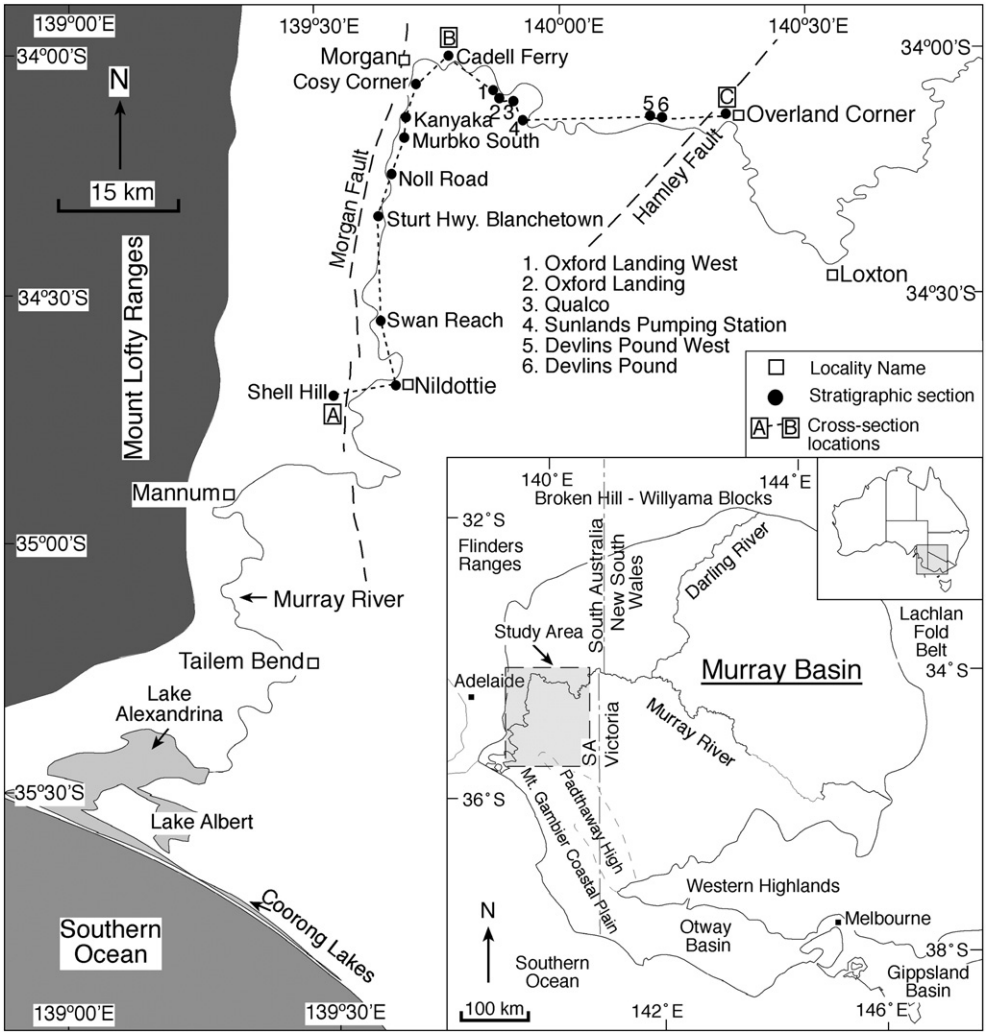

Fig. 1. Location of the Murray Basin in southeastern Australia, including the location of stratigraphic sections (Figs. 3 and 4) and cross-sections (Fig. 5) in this study.