# TERTIARY SEA LEVELS AND HEAVY MINERAL DEPOSITION IN THE EASTERN EUCLA BASIN, SA

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## INTRODUCTION

The Eucla Basin in southern Australia is a marginal basin that contains a sequence (up to 300 m thick) of marine, coastal and palaeochannel sediments of Tertiary age (Benbow *et al.* 1995, Hou *et al.* 2003a). Its northern margin extends ca. 2000 km from Western Australia to South Australia and contains a large onshore extent of Tertiary sediments characterized by a number of palaeovalleys extending landward in the Precambrian Yilgarn, Musgrave and Gawler Cratons (Figure 1). The present landscape is dominated by extensive tracts of Quaternary deposits largely superimposed on the Tertiary morphology. The eastern Eucla Basin is characterised by Tertiary coastal barrier systems of highly prospective beach placers with significant economic potential (Benbow 1990). Currently, heavy minerals (HM) in this region have become an important exploration focus, as several generations of HM-bearing shorelines have been recognised recently (Hou *et al.* 2003b, c). Heavy mineral sampling has provided a vector to such deposits (Ferris 1994, Hou *et al.* 2003c), but there is debate about the distribution and evolution of heavy mineral deposits. It is therefore important that a lithostratigraphic scheme be in place for the prospective rocks.

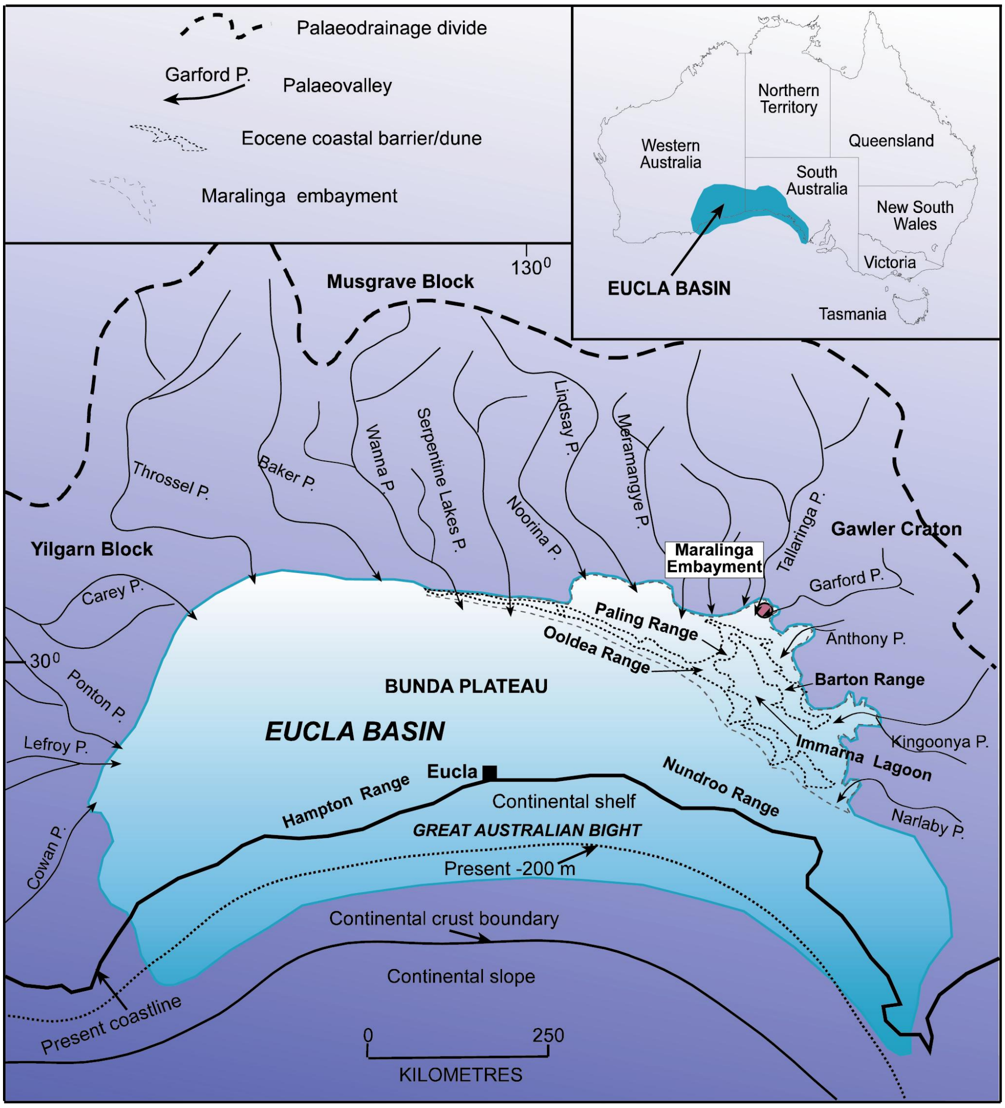


**Figure 1:** Eucla Basin and major adjacent palaeovalleys (after Hou *et al.* 2003c).

## INVESTIGATIVE METHODS

Examination of lithofacies, and paleontological, allo-stratigraphic and sequence stratigraphic frameworks from selected drillholes and a few outcrops across the eastern Eucla Basin has shed new light on the prospective rocks, and establishes a new sequence of Tertiary marine transgressions and deposition in the region (Figure 2). A palaeogeo-graphic reconstruction was processed in a GIS based on a digital elevation model, remote sensed imagery, geological and drillhole data and sedimentological analysis in which key sedimentary surfaces (disconformities, a tidal/wave ravinement surface, transgressive surfaces and maximum flooding surfaces) bound the sedimentary packages (Figure 3). A number of HM-bearing transects were created based on detailed drillhole descriptions, including micro-scopic study, to show the distribution of mineralisation.

## HEAVY MINERAL SANDS

Selected drillhole and cross-sectional distributions of heavy mineral anomalies (1-27% HMs) from the Ooldea and Barton Range areas (Figure 4) show that the placers occur either in the

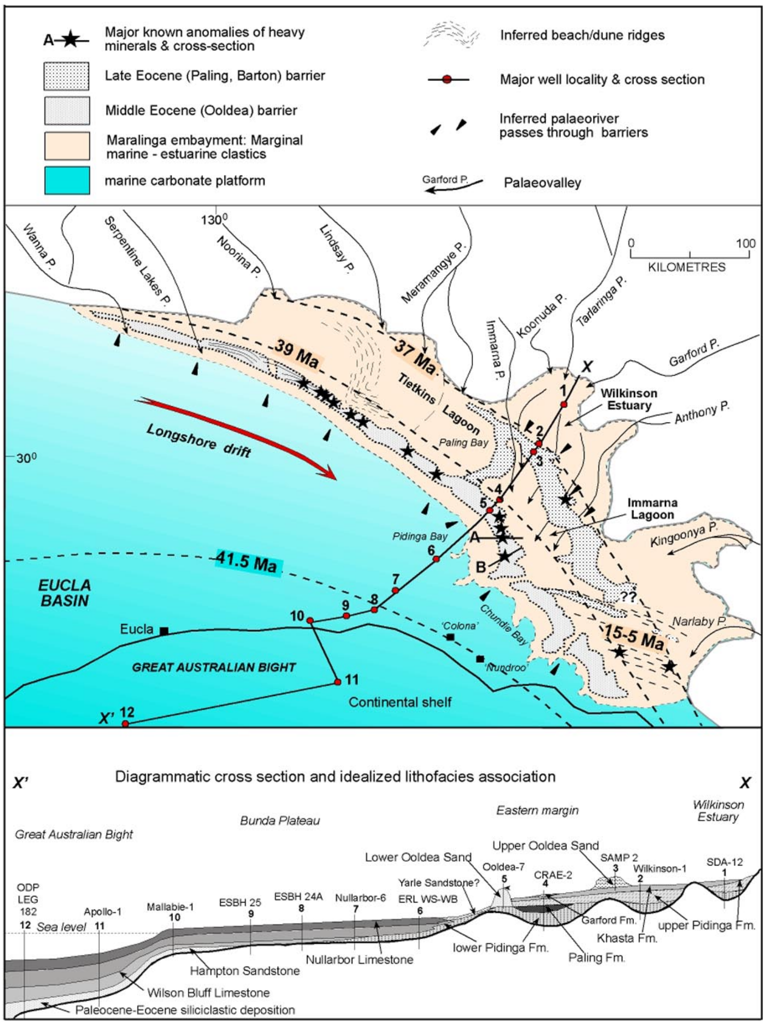


**Figure 2:** Tertiary geographical and lithofacies frameworks of the eastern Eucla Basin (after Hou et al., 2003c), including heavy mineral anomalies.

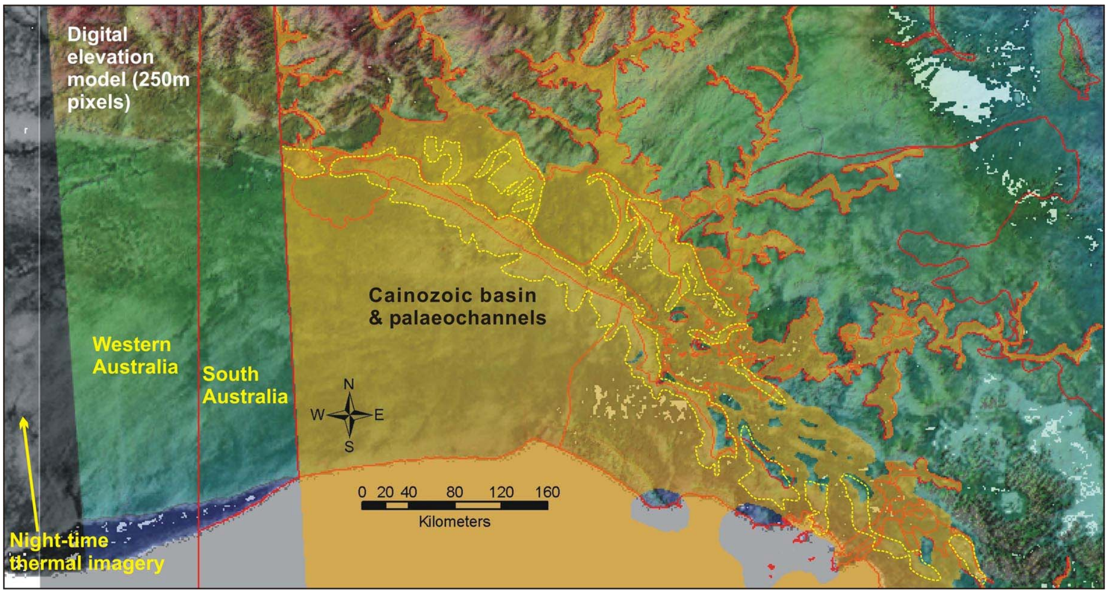


**Figure 3:** Comparison of the coastal barriers delineated from previous (red lines, SA_GEODATA) and this (yellow dash line) studies in GIS. Superimposed light tone (50% transparency) is the actual distribution of barrier deposits interpreted subsurface (yellow dash line). Note that there is up to 25 km difference.

upper part of thick barrier/dune sand bodies, often 20 m or more below the surface, or close to an erosional bedrock contact. Analogous to the beach placer deposits of the eastern Australian coast classified by Roy (1999), several types of heavy minerals deposits can be identified by sedimentological study (Hou *et al.* 2003c): (i) lag deposits along erosional disconformities and/or unconformities; (ii) transgressive deposits at the rear of highstand (swash-aligned) barriers, including those trapped near the palaeovalley passes; (iii) regressive deposits at the front of prograded barriers; and, (iv) aeolian deposits, as low-grade disseminated concentrations in transgressive dunes. Based on the interpretation of the depositional environments, the heavy minerals are probably accumulated in the Tertiary shorelines, defined as bodies of coastal sand, which here comprise beach, shoreface, barrier, dune, tidal inlet, washover and lagoonal facies (Hou *et al.* 2001), probably representing multiple higher order highstands (Hou *et al.* 2003b). Recognition of these coastal depositional environments within the different generations of shorelines gives meaning to anomalous intersections of beach placers and aids targeting of future drilling.

A new model of shoreline evolution, based on major third-order sea-level events, provides valuable geological information on the Tertiary landscapes and defines four generations of shorelines: Middle Eocene; Late Middle Eocene; Late Eocene; and Neogene. These shorelines are highly prospective for beach-sand-hosted heavy mineral deposits related to wave associated highstands of relative sea-level. Shorelines are associated with numerous palaeodrainage systems that drained areas of cratonic basement and supplied vast quantities of sediment to the basin (Ferris 1994). Concentrations of detrital rutile, zircon, ilmenite, and minor leucoxene and monazite (Figure 4) occur as beach placers in highstand strandlines of Tertiary age along these shorelines. These geomorphic features are excellent for the formation and localization of beach placers, mainly by longshore drift (Hou *et al.* 2003c).

## CONCLUSION AND FUTURE WORK

The eastern Eucla Basin has potential as a major new heavy minerals province in Australia. Here, detailed re-examination of the Tertiary lithostratigraphy and geography reveals a record of stepwise evolution of marine and non-marine environments for these potentially economical sediments. The new model of shoreline evolution in the eastern Eucla Basin has provided valuable geological information for the Tertiary landscapes. Significant anomalies in beach placers and related coastal deposits are associated with at least four third-order Tertiary shorelines, ranging in age from Middle Eocene to Early Pliocene. The region is highly prospective for beach-sand-hosted heavy minerals related to wave-associated highstands and rises of relative sea-level.

To date, identified high-grade anomalies of rutile, zircon, ilmenite, and leucoxene occur in shoreline deposits. Mineralized zones are thought to represent stacked shoreline facies that accumulated during marine transgressions in the Tertiary. The most prospective strata are the barrier and associated sands of Tertiary shorelines that were buried by voluminous sand dunes over 40 m.y. The geographic and stratigraphic distributions of heavy mineral-bearing sands in Tertiary sediments suggest contemporaneous transport through palaeovalleys predominantly from Precambrian cratons.

The widespread development of strandlines beneath the extensive sand dunes, and their possible role as major heavy mineral carriers, make them an important element and challenge in further exploration. The presence of thick cover (up to 100 m) at the axes of the sand ranges will obviously deter exploration for heavy minerals, but the impressive width of the barriers (up to 25 km) which blankets large areas of more shallow cover (< 40 m) suggests that the HM-bearing strandlines are detectable. The challenge for future exploration lies in discovering not only dune/barrier sands beneath cover, but also beach, shoreface, dune, tidal inlet, and washover sediments beneath thin cover. The use of high-resolution digital elevation models and ground magnetics, remotely sensed (e.g. NOAA and Landsat) night-time thermal imagery, IP and PGR in the areas of shallow cover may target strandlines developed in the high-energy beach facies. Future exploration should seek a greater understanding of the allostratigraphic significance of the Tertiary succession and apply a greater emphasis to palaeogeomorphic and palaeogeographic factors.

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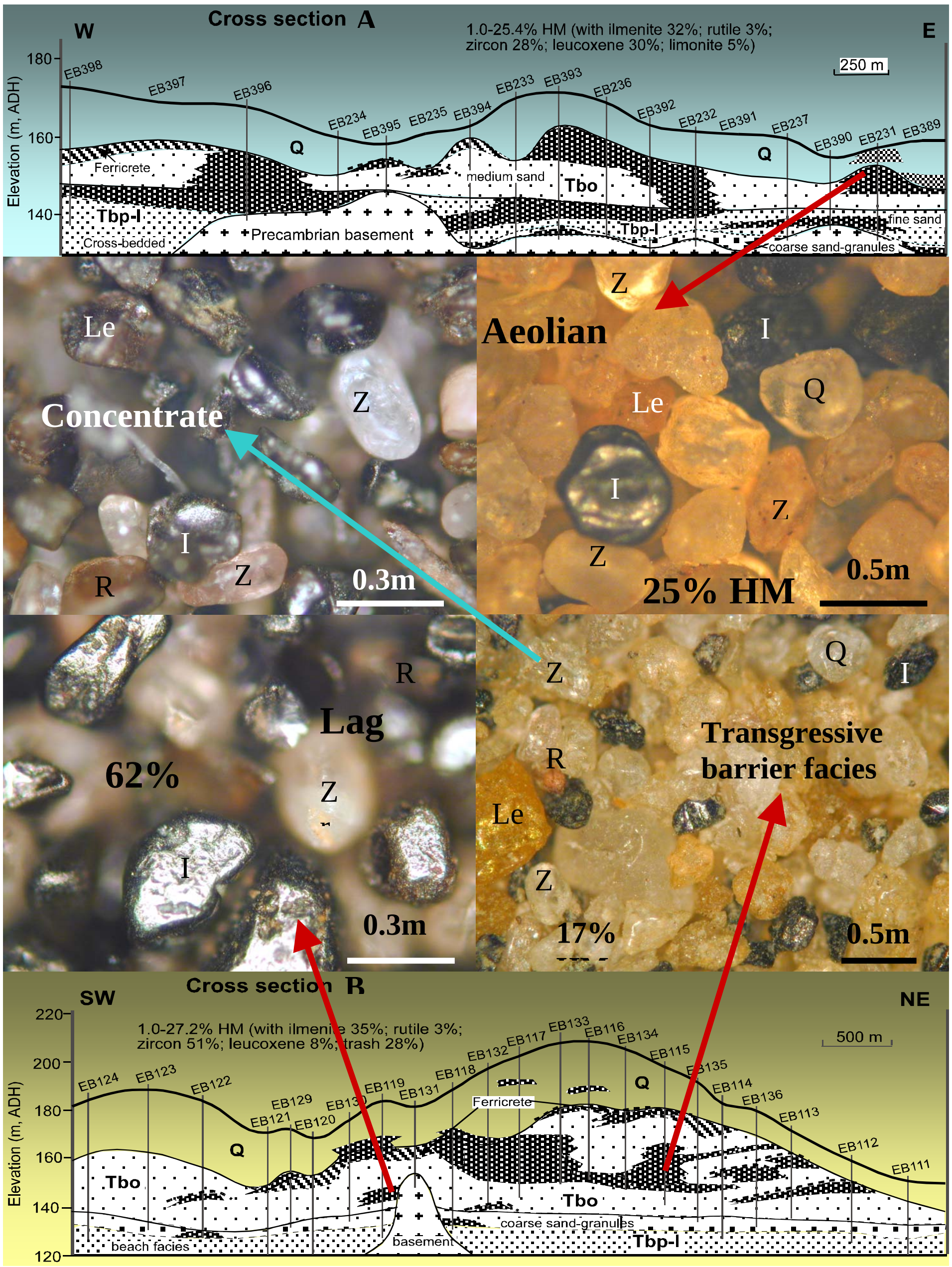


**Figure 4:** Selected geological sections and intersected heavy mineral-bearing sands (Zr, zircon; I, ilmenite; R, rutile, Le, leucoxene; Q, quartz; reflected polarised light. Cross-sections are located in figure 2).