

PALAEOCHANNEL EVOLUTION, NORTHWESTERN GAWLER CRATON, SOUTH AUSTRALIA

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INTRODUCTION

Tertiary palaeochannels, mostly discharging into the Eucla Basin, are widely distributed in the northwestern Gawler Craton (Benbow *et al.*, 1995). The palaeochannels present numerous exploration problems and opportunities, challenging geological, geophysical and geochemical exploration techniques. The channel fills have experienced varying degrees of weathering and styles of sedimentation. The following summary is based on palaeochannel studies in the region, including palaeochannel–landform mapping, palaeochannel characterisation and sedimentological studies (Clarke and Hou, 2000; Hou *et al.*, 2000, 2001a,b,c).

REGIONAL SETTINGS

Geology

The northwestern Gawler Craton is mainly composed of Precambrian gneiss, schist, granite and banded iron-formation, locally overlain by Palaeozoic, Mesozoic and Tertiary sedimentary rocks (Benbow, 1993). Tertiary palaeodrainages in the region

(Figure 1) have been mapped at the 1:250 000 and 1:1 000 000 scale (e.g. Benbow, 1993; Rogers, 2000). Tertiary sediments in the northwestern Gawler Craton and adjoining Eucla Basin margin infill the sites of palaeorivers and depressions carved into much older sediments and basement of the interfluvies.

Geomorphology

Most of the area is covered by Quaternary sand plains and dunes and regolith sheets, which obscure the Tertiary palaeochannels (Benbow, 1990). One of the most significant geomorphic features in the area is a string of playa lakes and lunettes developed in topographic lows, below which generally lie the Tertiary palaeodrainage systems. Other prominent landforms in the area include the parallel Ooldea and Barton ranges and the interconnecting Paling Range (Figure 1), which are well preserved coastal dunes or barriers of Late Eocene or Early Oligocene age (Benbow, 1990; Clarke and Hou, 2000). These remarkable landforms can be interpreted by considering their topographic relief, by applying Digital Elevation Models, and by interpreting

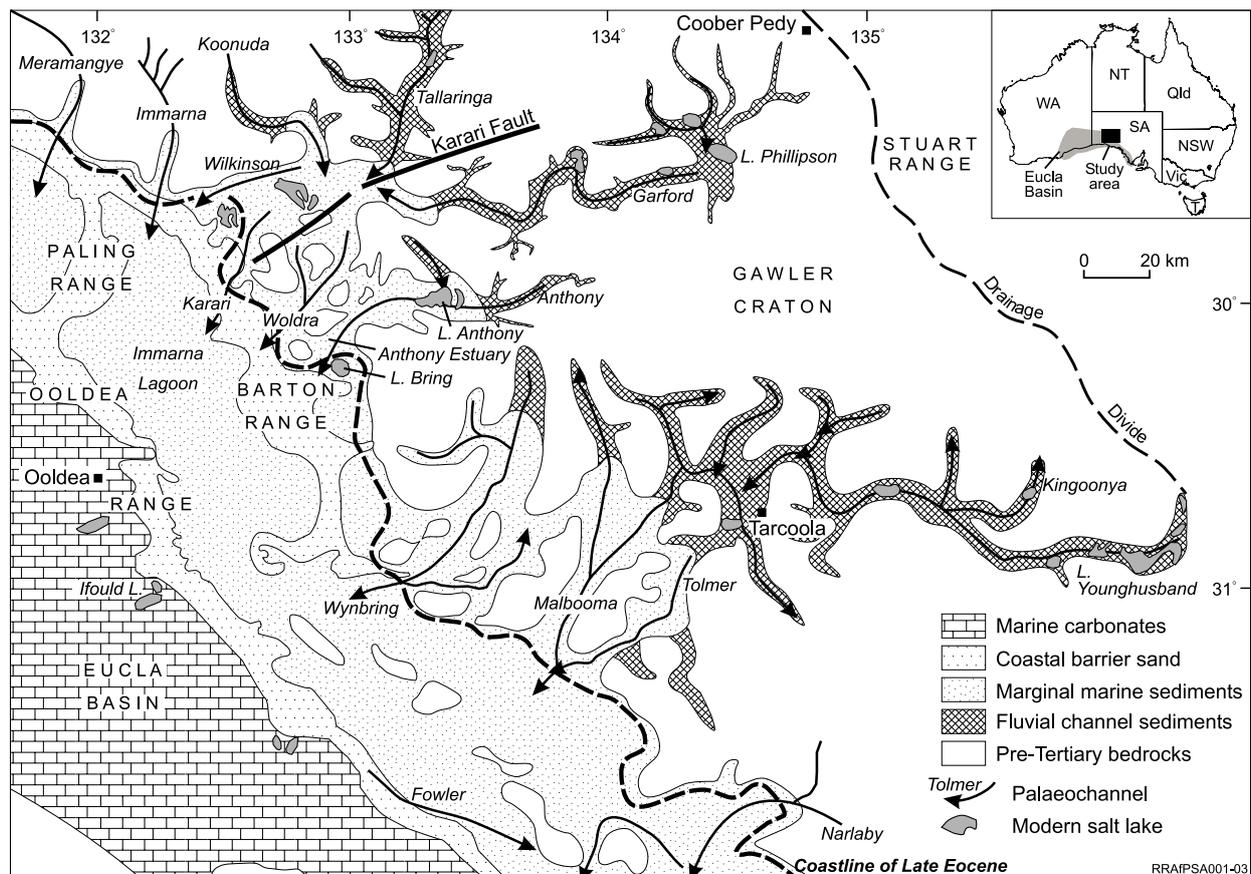


Figure 1. Palaeogeography of the palaeochannels draining the Gawler Craton region, showing the distribution of Tertiary marine, marginal marine, and channel sediments. Palaeochannel positions have been outlined by topography, geological maps, basement contours, drillhole data, multispectral scanner imagery, DEM, TEM, gravity, and existing palaeodrainage maps. (after Hou *et al.*, 2000)

Landsat and NOAA imagery (Hou *et al.*, 2000). Other major geomorphic features, such as ancient headlands and embayments, are also recognisable in the Tertiary coastal area.

Weathering and erosion

The depth of weathering is highly variable, ranging from a few metres to more than one hundred metres in bedrock-dominated areas (Benbow *et al.*, 1995). Lintern and Sheard (1998) described many examples of weathering profiles in the Gawler Craton, and provided an outline of regolith terminology. Deep weathering profiles capped by siliceous and ferruginous duricrust (Benbow *et al.*, 1995) have developed over different lithologies, including the crystalline basement and pre-Tertiary cover. Observations of weathered Quaternary cover sediments, unweathered Tertiary channel fills, and deeply weathered basement rocks in drillholes in the palaeochannels imply a major episode, or possibly several episodes, of deep weathering and erosion (Alley *et al.*, 1999). Siliceous and ferruginous rocks include both groundwater and pedogenic forms. Lateritic duricrust forms a blanket over most of the area; however, the thickness and composition of the lateritic duricrust vary with topographic position.

Physiography

The area lies on the southwestern slopes of the Gawler Craton drainage divide, in the arid zone of South Australia. The area has an annual rainfall of about 150 mm, with cold, wet winters and hot, dry summers. The Stuart Range forms a regional drainage divide between the Eyre Basin to the east and the Eucla Basin to the southwest. A number of elongate depressions extending between the Stuart Range and the Eucla Basin delineate a series of Tertiary–Quaternary drainage systems (Figure 1). These depressions are now largely filled with aeolian sand sheets and dunes. Scattered throughout the length of these topographic lows are numerous playas and salinas commonly underlain with silcrete, calcrete or gypcrete.

PALAEOCHANNELS

A number of palaeochannels have long been recognised and regarded as parts of larger, ancient drainage systems which flowed west or southwestwards to the Eucla Basin in Eocene to Miocene times (Figure 1). The dimensions of the channels vary greatly, with widths of the river valleys ranging from a few tens of meters to more than 30 km and depths of up to 120 m. In length, most of the main channels extend for more than 100 km. These large sizes reflect past conditions of high precipitation as implied by the fossil evidence. The principal direction of drainage is towards the southwest, but there is considerable variation, such as towards the northwest and south (Figure 1). The palaeochannel mouths are characterised by a series of ancient estuaries (e.g. Wilkinson and Anthony) and coastal barriers (Ooldea and Barton ranges). Between the coastal barriers lie NW–SE trending lagoons (Figure 1).

CHANNEL FILLS

Tertiary sedimentation was widespread in the area, leading to the deposition of four major units (Hou *et al.*, 2003): the Eocene Pidinga Formation (mainly fluvial carbonaceous sediment), Khasta Formation (estuarine sands) and Ooldea Sand (coastal barrier sands), and the Miocene Garford Formation (dominantly lacustrine clays). Although the lateral and vertical variation in lithology of the channel-fills makes intraformational correlation difficult, these four major units can readily be recognised and correlated throughout the region (Hou *et al.*, 2001a). The thickness of channel fills normally ranges from several metres to 50 metres, but locally exceeds 80 metres. The sedimentary facies change markedly both vertically and laterally within the channels due to the complexity of fluvial sedimentation (Figure 2). Facies relationships are complex between the principal units of the palaeochannels. Boundaries between units are often erosional and in places a channel contains only one of these diverse rock types, testifying to the intermittent character of stream activity (Figure 2).

PALAEOCHANNEL EVOLUTION

The palaeorivers drained a large catchment in which there were a wide variety of sedimentary environments (Figure 1). The Pidinga Formation was deposited in a range of environments, from fluvial, estuarine to marginal marine. Carbonaceous materials attest to a dense vegetation cover supported by a humid, tropical to subtropical climate (Alley *et al.*, 1999). The Khasta Formation was deposited in estuarine to marginal marine environments. Locally, the Ooldea Sand in the Ooldea, Paling and Barton ranges were deposited in energetic upper shoreface and beach environments during development of the Tertiary coastal barriers. The interdune area was probably occupied for some time by a large lagoon (Immarna lagoon in Figure 1). The Garford clay and carbonate sequences were deposited in extensive lakes and rivers. Reversal of flow is inferred from the Garford Formation; from westerly isolated and abandoned channel and lacustrine deposits, to easterly relatively continuous and elongate channel deposits. Subsequent drying of these lakes and channels led to deposition of regressive dolomitic clastic and chemical sediments of the Garford Formation.

When the Tertiary palaeochannels formed and for a time thereafter, the climate of southern Australia was warm and wet (e.g. Alley *et al.*, 1999; Frakes, 1999). The effects of this and later climatic regimes on weathering, erosion and sedimentation were of great significance. Key events in the history of the craton and the Eucla margin were episodic duricrust-forming episodes during the Early and Late Eocene, the Middle Miocene and the Late Pliocene (e.g. Frakes, 1999). The evidence from Eocene megafloora and microfloora suggests at least local warm–temperate rainforest conditions (Alley *et al.*, 1999); this is supported by the widespread accumulation of lignites along the southern continental margin.

Subsidence in the Eucla Basin probably commenced in the Cretaceous–Paleocene shortly before the earliest palaeovalleys

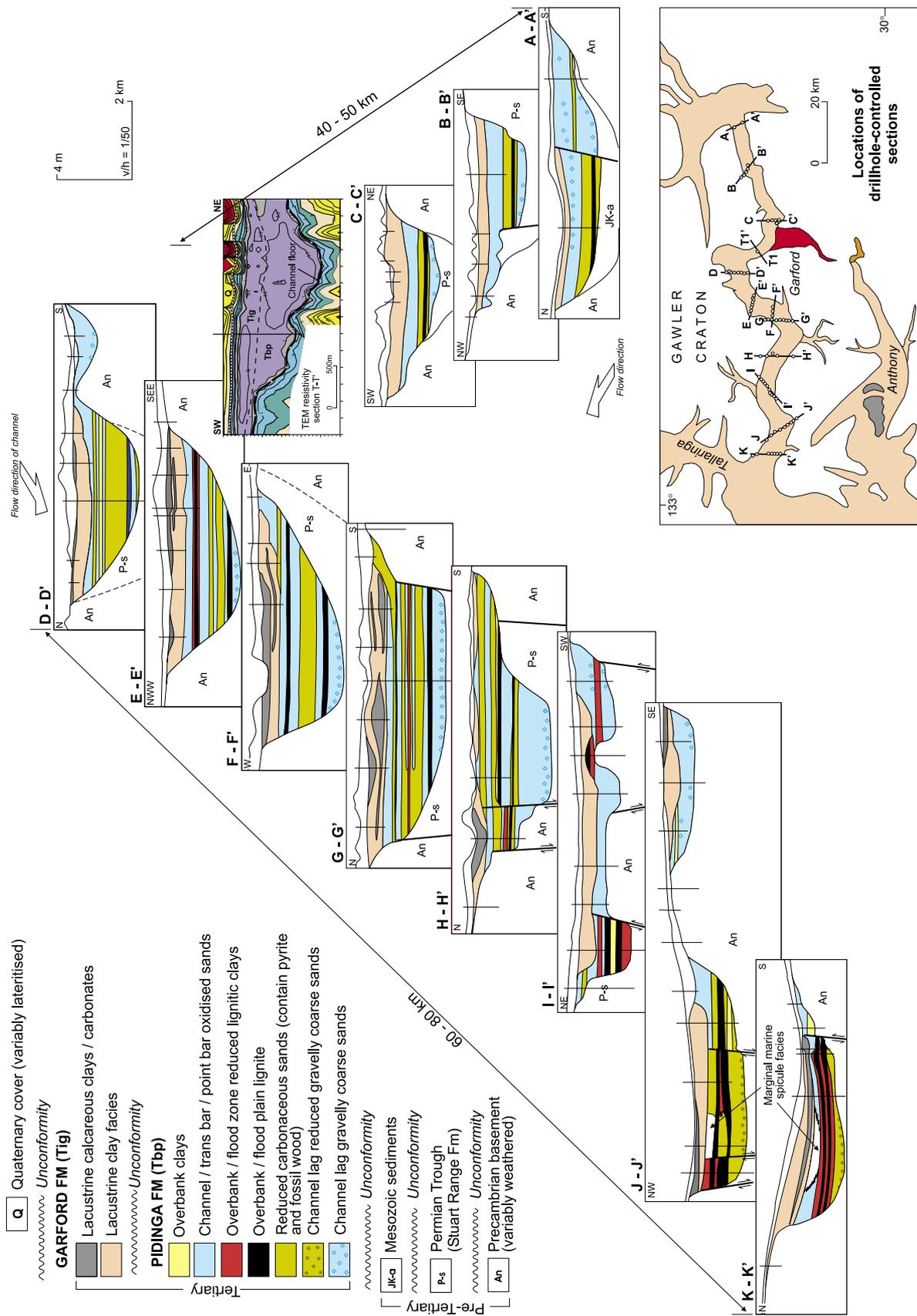


Figure 2. Sequential cross-sections through length of Garford Palaeochannel. (after Hou *et al.*, 2001c)

formed, with on-going slight epeirogenic uplift of the cratonic margin (Frakes and White, 1997) and on-going incision of the valleys (Hou et al., 2001a). Prior to the Tortachilla marine transgression, deposition of fluvial coarse materials was limited to the valley thalweg. This implies that unless the fluvial deposits were originally thicker and subsequently eroded, there had been no significant fluvial aggradation in the landward extremity of the incised valley either during sea-level lowstand or during the subsequent Tortachilla sea-level rise (Hou *et al.*, in press). Then, the basin and channel sediments thicken and are inclined gently in a seaward direction during following Tuketja Transgression. Erosion of the Eocene sediments occurred in the Middle Miocene and Early Pliocene when lacustrine sedimentation dominated in the lakes and channels. During the Late Miocene–Early Pliocene, the palaeochannels were fragmented into chains of relatively small lakes in which dolomite was deposited.

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