# COMPLEX DEPOSITIONAL LANDSCAPES OF THE WESTERN AUSTRALIAN WHEAT BELT

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## INTRODUCTION

An extensive network of valleys and palaeovalley fills occurs across the Western Australian Wheat Belt where underlain by the Yilgarn Craton. The palaeovalleys have a complex architecture and relationship to the present landscape, the result of a long evolutionary history, inferred as extending at least as far back as the Jurassic (Clarke & Alley 1993). Most are inactive, acting as sumps for surface drainage. The lower reaches of some are loosely associated with modern drainages along the west and south coast. Many studies of hydrogeology of the region do not consider the role played by thick palaeovalley fills (e.g., George 1993), however the literature indicates that these are widespread in all parts of the eastern wheat belt and, in the western part, may be under-reported because of the low textural maturity of the sedimentary infill and the strong weathering overprint (de Broekert 2003). A useful summary of the architecture of wheat belt valleys is by Commander *et al.* (2001).

## PALAEODRAINAGE CLASSIFICATION

Several classifications have been proposed for the palaeodrainage systems. The extremely low-relief nature of the landscape and the very broad interfluves makes for changes in the position of drainage divides of 10's of km in the interpretations of different authors. For the Yilgarn as a whole, van de Graaff *et al.* (1977) recognised but did not name three main divisions: an eastern system (associated with the Eucla Basin); a western system (associated with the Perth and Carnarvon basins); and, a northern system (associated with the Canning Basin). They also recognised a long, narrow drainage system associated with the south coast, but did not clarify whether it was a separate division in its own right or associated with the eastern or western systems.

Mulcahy & Bettenay (1972) had earlier divided the drainages somewhat differently. They recognised and named the Eucla (equivalent to the eastern division of van der Graaf *et al* 1977), south western (equivalent to the southern half of the western division of van der Graaf *et al* 1977 with the inclusion of the south coast drainages), and Murchison (equivalent to the northern half of the western division of van der Graaf *et al* 1977) divisions. They also recognised a Pilbara and Canning division, roughly equivalent to the northern division of van der Graaf *et al* (1977).

I propose for this discussion to recognise three major divisions, based on those of van de Graaff *et al.* (1977). These are: an eastern (which includes the south coast) associated with the Eucla Basin (see Clarke *et al.* 2003); a western, associated with the Perth and Carnarvon basins; and, a northern, associated with the Pilbara region and Canning Basin (Figure 1). The Western Australian Wheat Belt occurs over the southern part of the eastern and most of the western divisions. These drainage divisions may not have been completely stable over time. For example, Figures 5 and 6 of Commander *et al.* (2001) show, following Beard (1999), how the upper reaches of the south-draining Eocene system was captured and diverted to the west during the Miocene. This drainage evolution will lead to dismembered palaeovalley fills in the landscape and palimpsest deposits.

## PALAEODRAINAGE ARCHITECTURE

### Eastern division

Palaeovalley fills of the eastern division have been reasonably well studied and documented (Figure 2). Forming the palaeocatchment to the Eucla Basin (Clarke *et al.* 2003), the palaeovalleys have largely been filled by a succession of Eocene marine to non marine sediments. Two transgressions are recognized—Miocene fluvio-lacustrine sediments; and Pliocene-Holocene playa lake sediments—totalling up to 100 m in thickness. Broadly similar valley fills will be found as far west as Walpole on the south coast. Those of the south coast may, however, lack the older (e.g., Pliocene) playa lake sediments as the very limited palynological data suggests that humid vegetation persisted into the Pliocene (Bint 1981). The higher rainfall along the south coast increases westwards and some valleys may have been partly incised (Beard 1999). Wheat belt valleys north of the Stirling Ranges that contain over 60 m of Eocene sediment (Commander *et al.* 2001) are part of this eastern system.

*In:* Roach I.C. ed. 2005. *Regolith 2005 – Ten Years of CRC LEME*. CRC LEME, pp. 49-54.

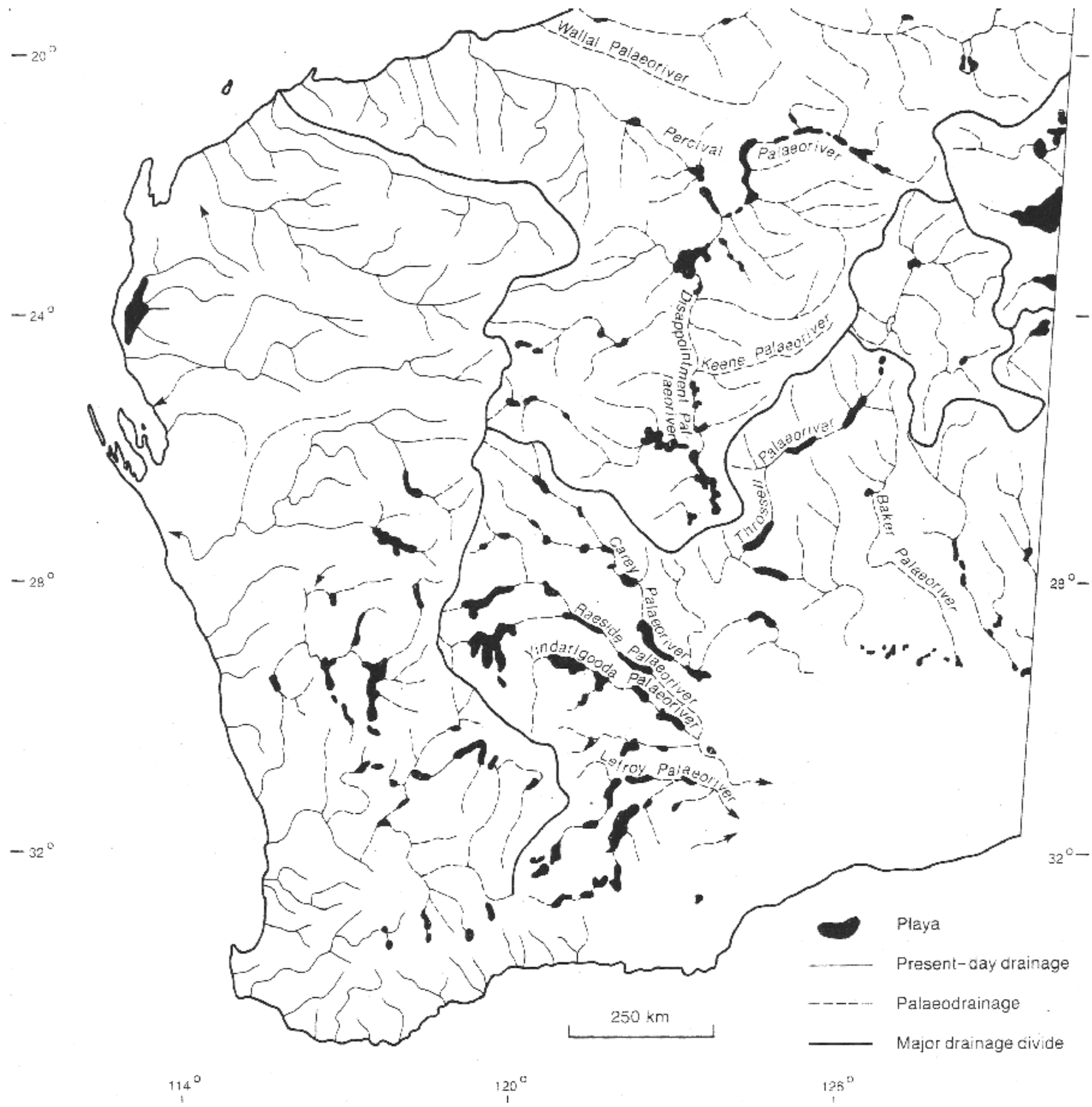


**Figure 1:** Location of the three major drainage systems on the Yilgarn Craton and adjacent areas discussed in the text. The eastern system is peripheral to the Eucla basin, the western system to the Perth and Carnarvon basins, and the northern to the Canning Basins. Modified from van de Graaff *et al.* (1977).

**Western division**

Eocene sediments have not been reported from any of the palaeodrainage systems, possibly because they have been removed (Beard 1998). However, fossiliferous (non-marine bivalves and plants) Eocene sediments occur as silcrete caps on interfluves (Wild & Backhouse 1976). The freshwater bivalves indicate that the Eocene sediments were seasonally water-logged, pointing to inversion of former valley bottom to their present position as ridges.

Fill architecture of the palaeovalleys of the western division has been very poorly documented compared to those of the eastern. Only the fill of the Salt River palaeovalley has been studied in any detail (Salama 1994, 1997). The Salt River is the middle reaches of a drainage system whose active lower reaches form the Avon River and whose inactive head reaches the Yilgarn palaeodrainage. Up to 50 m of sediments are present in the Salt River palaeodrainage at Yenyening Lakes, consisting of sands, clays, and peat. The oldest sediments are Mio-Pliocene (Figure 3).

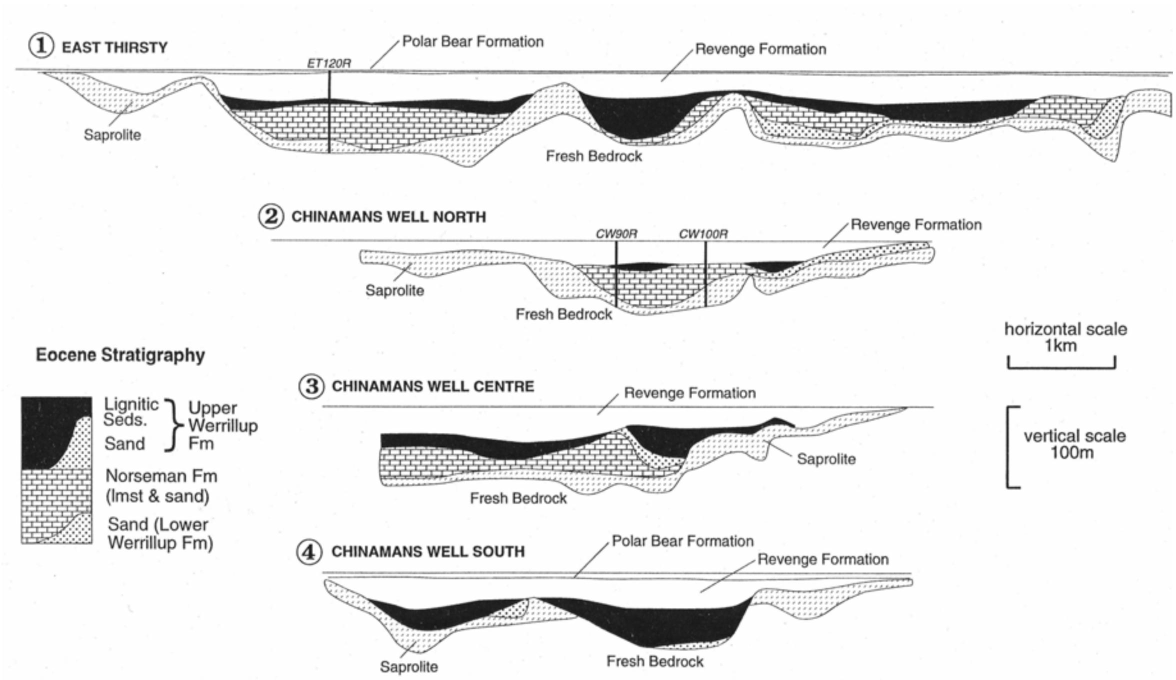


**Figure 2:** Stratigraphic architecture of the infill of the Cowan palaeovalley near Norseman (after Clarke *et al.* 1996).

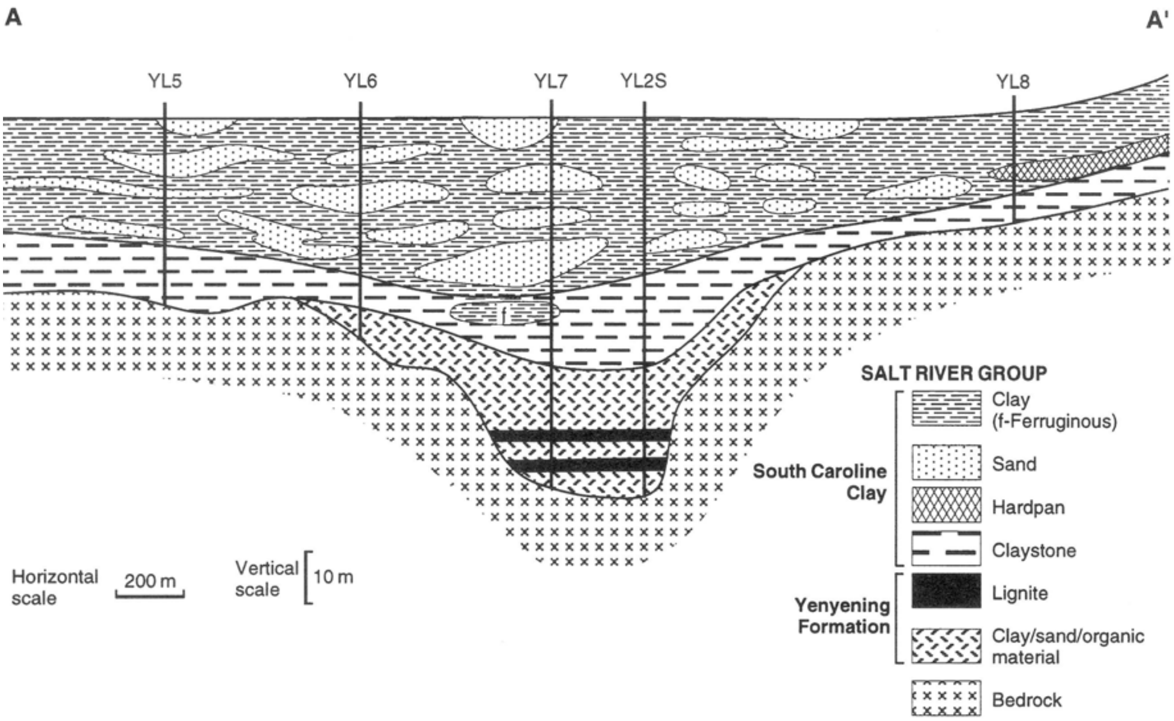


**Figure 3:** Sediment filling the Salt River Palaeodrainage at Yenyening Lakes (after Salama 1997).

Tributary palaeovalleys have thinner but coarser infill successions, with 20 m of conglomerate, sandstone, claystone, and minor peat being reported from Wallatin Creek (Salama 1997). These sediments are Pliocene to Holocene in age.

De Broekert (2003) described structurally controlled bedrock relief beneath valleys at Yornaning with the significant thicknesses occurring off axis (Figure 4), rather as has been observed in the Wellington area in the eastern highlands. There has also been incipient development of relief inversion through removal of the former interfluves of exposed bedrock. Together these observations indicate that the western drainages have undergone significant uplift and inversion of relief since the Eocene, leaving former valley floors as interfluves. Miocene to Pliocene sediment filled the valleys; these are now being removed by headward progression of knick-points in major active drainages such as the Avon River.

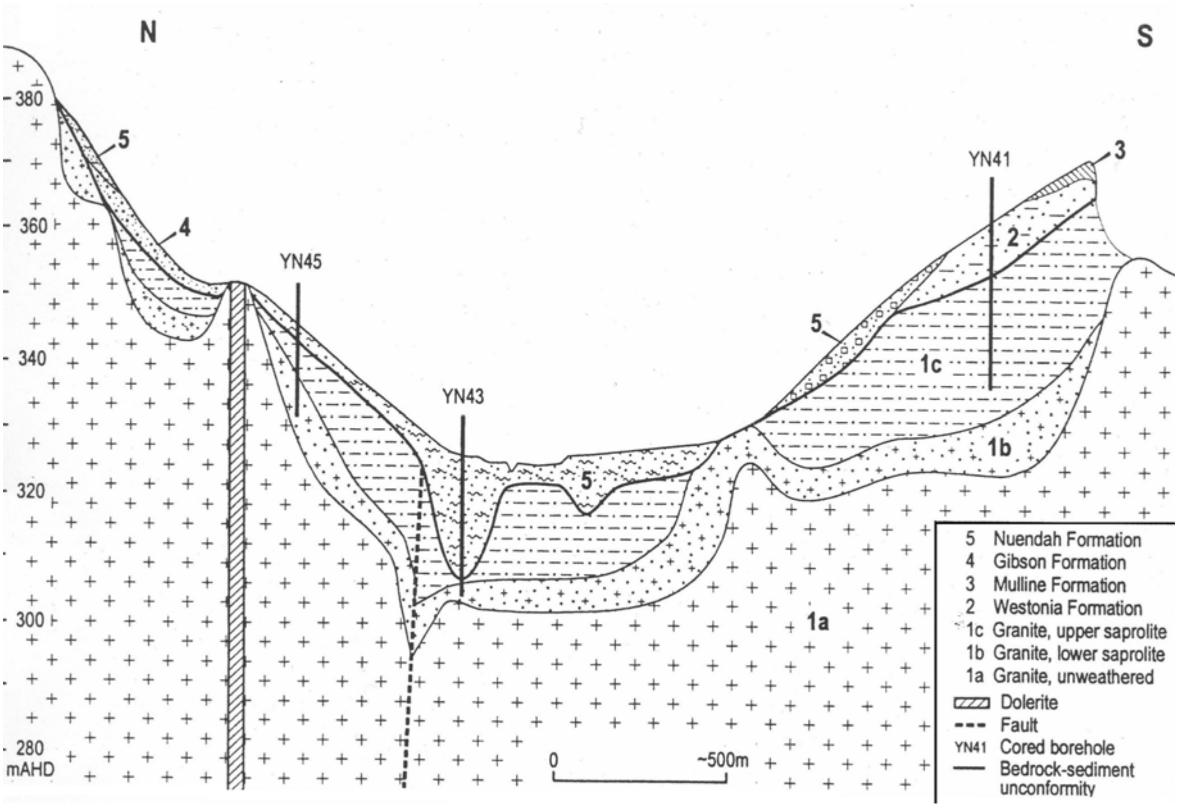


**Figure 4:** Structurally controlled bedrock relief beneath valleys at Yornaning with the significant thicknesses of sediments occurring both on and off the axis of the modern drainage (modified from de Broekert 2003).

The presence of inverted Eocene valley floors, incipient inversion of younger sediments and major shifts in position of valley floors all indicate that modern morphology is a poor predictor of regolith thickness in general and sediment thickness in particular. However, despite the problems with such methodologies, use of surface data, both soils and DEMs as the prime predictors of subsurface fill thickness continues to be recommended (e.g., George & Coleman 2001, Commander *et al.* 2001). While such approaches are a partial solution, exclusive reliance on them must be abandoned if significant progress is to be made in understanding and mapping groundwater flow and salinity in the WA wheat belt.

**HYDROGEOLOGY**

All the palaeovalley fills contain hypersaline aquifers with the main palaeovalleys acting as major conduits (Commander 1989). The distribution of tributary palaeovalleys is poorly known and, as noted by de Broekert (2003) the extent of thick Cainozoic sediments is likely to be underestimated because of the difficulty in differentiating weathered, structureless compositionally mature but texturally immature sediments from saprolite. However, they are likely to be encountered at a range of scales and in conjunction with bedrock features such as fractures and dykes (Clarke *et al.* 1998), are the likely the dominant factors in groundwater flow (Salama *et al.* 1993b).

Most of the active drainage systems in the Wheat Belt are saline or brackish (Commander 1989). The close association between active rivers and inactive palaeodrainages in the upper reaches suggests that discharge of hypersaline water from palaeodrainages into the modern rivers is a major source of their salinity.

The role that these systems play in the dryland salinity of the western Australian wheat belt has been recognised by Coram *et al.* (2000). However these authors divided the ground water flow systems of the palaeodrainage fills between the intermediate-scale GFS found in “palaeochannels” of the weathered Precambrian rocks (p. 5-6) and the regional groundwater flow systems of the “Bremmer” (*sic.*) basin (p. 17-

18). The Bremer Basin and its peripheral palaeodrainage now form the western extremity of the Eucla Basin (Clarke *et al.* 2003). Ideally, palaeovalley related systems should form a class of their own. George and Coleman (2001) describe how anthropogenic changes to recharge and runoff has resulted in oversaturation of these palaeovalley fills and surface saline discharge.

## CONCLUSIONS

- Palaeovalley fills of the Western Australian Wheat Belt fall into two divisions: those of the eastern division along the south coast and those of the western division.
- Those of the eastern division will have Eocene to Holocene infills very similar to those of the Lefroy and Cowan palaeovalleys. Unlike those of the more arid interior, post infill incision means that the thickness sediments (approaching 100 m in places) will not always occur in the valleys of the modern landscape.
- Those of the western division will have Miocene to Holocene stratigraphies similar to those of the Salt River system. Extensive incision and inversion of the landscape post Eocene means that Eocene sediments occur on the interfluves and thick valley fills are commonly present off the axis of modern valleys.
- Although different from that of the eastern palaeovalleys, the western palaeovalley fills have an architecture at least, and probably more complex, than those of the east. Modern topography is a poor guide to palaeovalley fill geometry, which may exceed 50 m.
- Headward erosion of palaeovalley fills by major wheat belt rivers means that increases in saline discharge from the palaeovalley systems is likely to have a significant risk in increasing salinity in active rivers.
- The importance of these complex valleys fills to regional and intermediate scale GFS has been acknowledged in the standard compilations of Australian GFS and salinity.
- Management plans for salinity in the WA wheat belt *must* include the mapping of palaeovalley systems and characterisation of their materials if they are to accurately encompass the dynamics of salt and water movement in the landscape.

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