The Collie Coalfield: a starting point for Permian Gondwana correlation in a transtension extensional basin

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Abstract

A sequence from Asselian to approximately Ufimian is preserved in the Collie Basin by post-depositional extensional faulting. It is proposed that many Indian and Antarctic Permian basins result from the same style of extensional tectonics and contain similar Permian sequences. The Collie Basin sequence contains ten palynological zones that are extrapolated into the Perth and Carnarvon Basins. Tentative correlations are made with comparable Gondwanan coalfields in India and southern Africa, based on published palynomorph range charts, and allow speculation on coeval depositional and palaeoclimatic regimes.

KEYWORDS: Collie Basin, Permian, palynological correlation, Gondwana, coal, transtension extension tectonics, Western Australia.

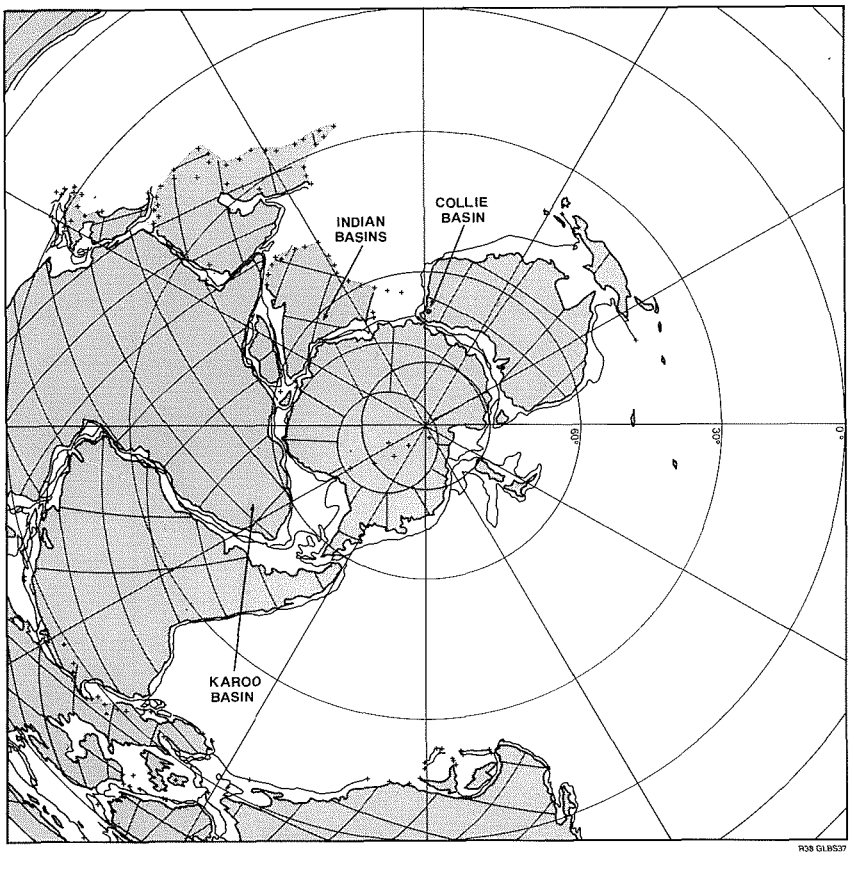


Figure 1. The Collie, Indian, and Karoo Basins located on a polar projection of Early Permian Gondwanaland

The Collie Basin (Figs 1 and 2), southwestern Australia, is an outlying relict of a once much larger Permian epicratonic sag basin. It contains a typical Permian sequence of basal diamictite (up to 30 m thick), overlain by up to 300 m of coal-capped periglacial deltaic and fluvial sedimentary rocks (Sequence P1) and 900 m of coal-bearing alluvial siliciclastic rocks (Sequences P2 and P3; Fig. 3; Le Blanc Smith, 1993). The strata are preserved in a post-depositional, fault-bounded extensional structure within the Archaean crystalline basement as a consequence of right-lateral shear in a transtensional setting (Figs 2 and 4). A similar genesis is envisaged for many Permian coalfields, particularly those of peninsular India and possibly Antarctica.

In the Collie Basin northwesterly striking, steeply dipping, normal-slip faults are dominant, and display differential displacement, stepping, and instances of scissoring in response to weak folding. Rare, small-displacement reverse faults strike to the northeast. Strata generally dip to the southwest and contain up to 74 m of coal in 60 principal coal seams between 0.5 and 13 m thick. They are overlain by a thin veneer of horizontal Cretaceous deposits. Vitrinite-reflectance data from the Collie Basin presented by Sappal (1986) indicate a maximum coal-burial depth of nearly 8 km (Le Blanc Smith, 1993).

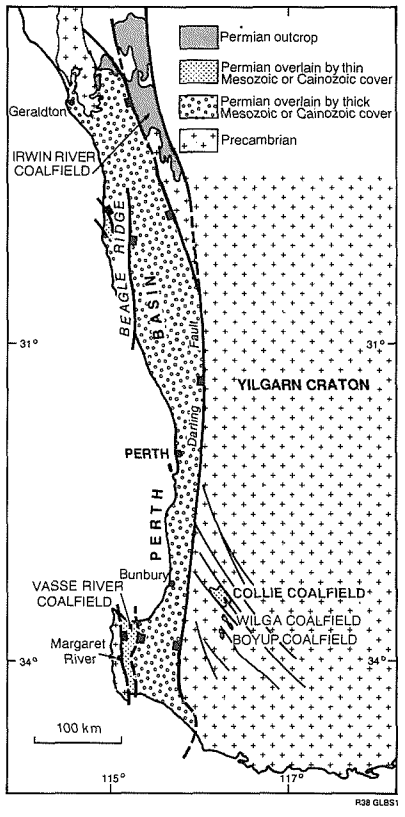


Figure 2. Location of the Collie Coalfield and fault-bounded Permian strata, southwestern Australia

Palynostratigraphy

A number of deep, fully cored boreholes drilled in the Collie Basin have allowed detailed subdivision of the sequence using palynomorphs. Ten palynological zones ranging approximately from the Asselian to the Ufimian were used by Backhouse (1991) for correlation within the basin (Fig. 3). This zonal scheme has been successfully extrapolated from the Collie Basin for over 900 km across a Permian depositional dip section: from the proximal Vasse Coalfield in the southern Perth Basin, northwards through the Irwin River Coalfield, and into the largely marine Carnarvon Basin. Marine faunas in the northern Perth and Carnarvon Basins, recently reviewed by Archbold et al. (1993), provide valuable age control for the palynostratigraphic units.

A suspected lacuna exists within the Collie Group, coincident with the base of the *Didecitriletes ericianus* Zone and a jump in vitrinite reflectance from 0.4 to 0.6%. The sequence in the southern Perth Basin extends 800 m higher than the top of the Collie Group into younger Permian sediments with *Dulhuntyispora parvithola*, which places them in upper Stage 5 of the eastern Australian palynostratigraphic scheme of Kemp et al. (1977) and Price (1983). In the northern Perth Basin, the Wagina Sandstone, also of Late Permian upper Stage 5 age, overlies the marine Carynginia Formation, a unit that on current evidence does not extend above the *Praecolpatites sinuosus* Zone (Backhouse, 1993). The subsurface Permian of the Carnarvon Basin is not fully investigated, but at least 1800 m of largely marine sediments are present in the Kennedy Range area between the base of the *Pseudoreticulatispora pseudoreticulata* Zone and the *Microbaculispora villosa – Dulhuntyispora granulata* Zone level. This interval is represented by approximately 600 m of coal-bearing sediments in the Collie Basin. Further north there is evidence for a lacuna in the mid Permian, comparable in age with the missing section beneath the Wagina Formation in the Perth Basin.

Gondwanan correlation and palaeoclimate

Permian palynofloras are strikingly similar in western Australia and the Gondwanan basins of India and southern Africa to the west. Correlation between these sequences in finer detail may provide evidence for the suspected lacuna below the *D. ericianus* Zone. Some of the Collie palynostratigraphic biohorizons, particularly in the Early Permian, are recognizable in studies on the Karoo sediments of southern Africa by Anderson (1977), Falcon (1975), and Falcon et al. (1984), and confirm that deposition of Sequence-P1 was broadly contemporaneous in southern Africa and western Australia (Fig. 3).

The *P. pseudoreticulata* Zone is equivalent to the construction phase of the periglacial alluvial deltaic platform in western Australia, whereas it equates to the transgressive inundation of equivalent platforms in the northern

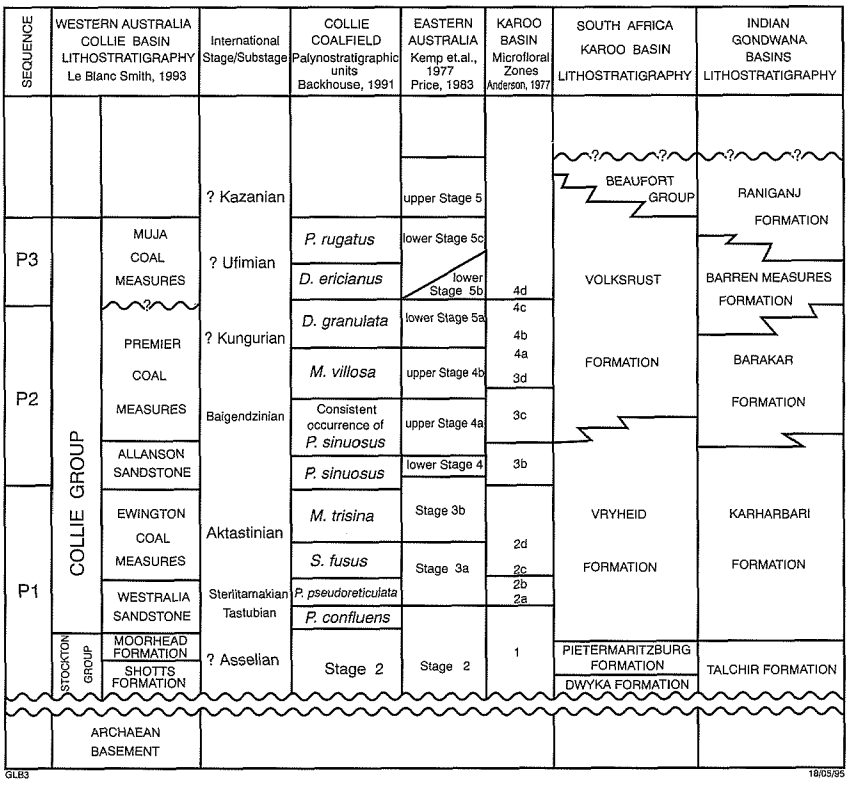
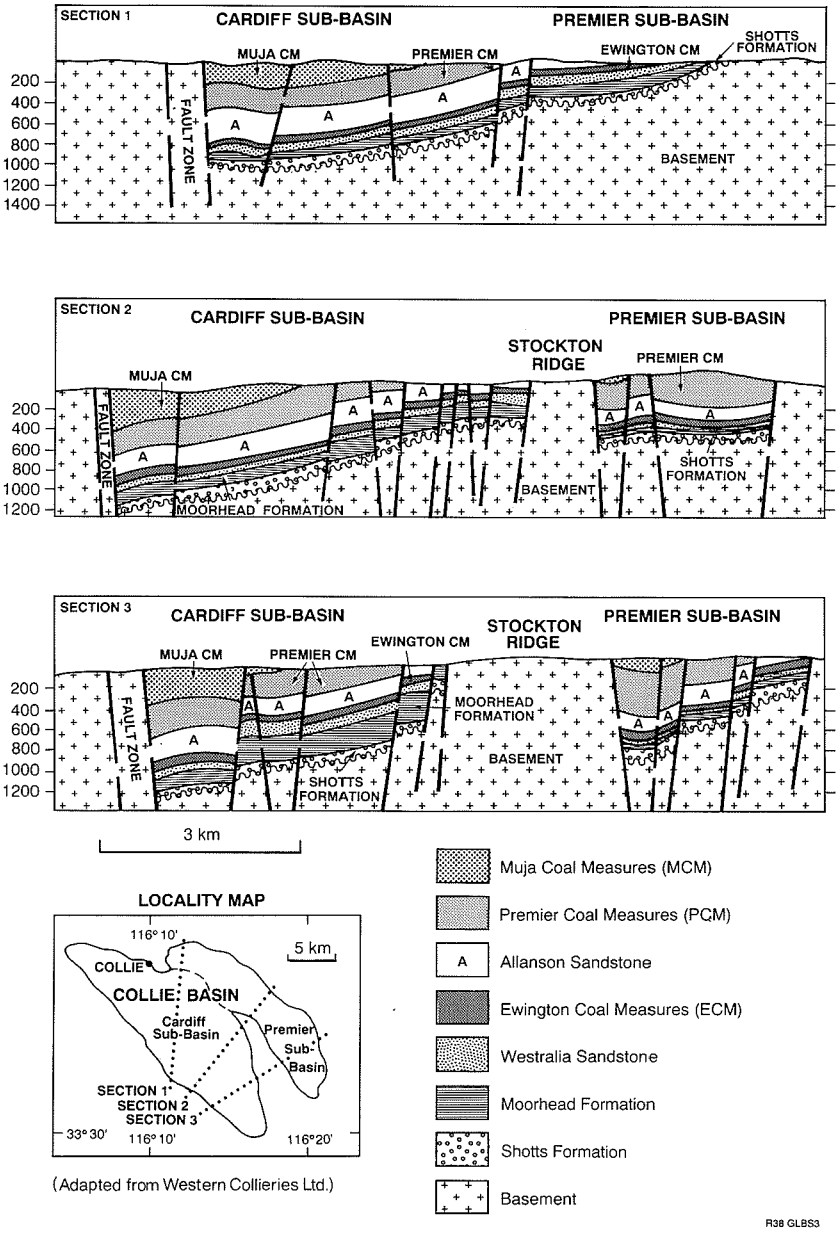


Figure 3. Provisional correlation of Permian palynostratigraphic zones and rock stratigraphy

Karoo Basin and the accumulation of the Number 1 and 2 Seam coals of the Witbank–Transvaal Coalfield, and probably the Karharbari Formation of India. The *Striatopodocarpites fusus* Zone marks the earliest significant peat accumulation in western Australia in the Ewington Coal Measures of the Collie Basin and the Irwin River Coal Measures of the Perth Basin. The base of this zone correlates with Seam Number 3 of the Witbank–Transvaal Coalfield (Falcon et al., 1984). Further, the *Praecolpatites sinuosus* Zone closely overlies the Ewington and Irwin River Coal Measures, and correlates with palynomorphs of the Number 5 Seam of the Witbank–Transvaal Coalfield.

Provisional broad correlations equate the Ewington Coal Measures (Collie Basin) with the Irwin River Coal Measures (Perth Basin), Karharbari Formation – Lower Barakar Stage (numerous Indian basins), and the Vryheid Formation (Karoo Basin). The palynological sequences of central and eastern Australia can also be broadly correlated with the Collie Basin, but further work is required to establish precise zone boundaries in those areas.

There is a close parallel between the early palaeoenvironments of deposition of southern Africa and western Australia (Le Blanc Smith, 1980a,b,c, 1993; Le Blanc Smith and Eriksson, 1979); however, palynological correlations suggest that the onset of substantial peat accumulation commenced earlier in southern Africa than in western Australia. One inference of this is that the global Permian climatic amelioration probably commenced in the west of Gondwana (southern Africa) and progressed eastwards, through the Indian subcontinent to western Australia and on to eastern Australia.



(Adapted from Western Collieries Ltd.)

Figure 4. Rock stratigraphic and structural sections of the Collie Basin. From Le Blanc Smith (1993)

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