Further isotopic evidence for the existence of two distinct terranes in the southern Pinjarra Orogen, Western Australia

by

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Abstract

Two samples from the crystalline basement of the Vasse Shelf in the southern part of the Perth Basin have Sm–Nd model ages (T_{DM}) of 2011 Ma and 2018 Ma (T_{CHUR} ~1715 Ma). These dates are similar to those determined for crystalline rocks elsewhere in the Pinjarra Orogen, including the Bunbury Trough, but are older than those of the Leeuwin Complex. The contact between the Leeuwin Complex and older portions of the Pinjarra Orogen apparently follows the Dunsborough Fault tectonic zone.

KEYWORDS: Geochronology, Leeuwin Complex, Perth Basin, Pinjarra Orogen, Sm–Nd, Vasse Shelf.

Several recent papers have considered the evolution of the southwestern corner of Western Australia (Fig. 1), mostly in the context of broad-scale accounts of Proterozoic evolution of the Australian continent (Page et al., 1984; Fletcher et al., 1983, 1985; McCulloch, 1987). There is general agreement that stabilization of the Yilgarn Craton was complete by about 2500 Ma and that the Pinjarra Orogen developed in two distinct stages: the crystalline basement of the Perth Basin forming and stabilizing between about 2200 Ma and 1100 Ma, and the Leeuwin Complex forming less than 1100 Ma ago. However, the validity of this three-stage sequence has been open to question because the geochronological database for the Pinjarra Orogen is quite limited.

New zircon U–Pb ages between about 450 Ma and 600 Ma for samples from two widely spaced localities in the Leeuwin Complex (Fig. 1) were quoted by Wilde and Murphy (1989), who have recently studied and mapped the complex in considerable detail. These ages are consistent with the available Sm–Nd model ages of about 1100 Ma (T_{DM}; see Table 1) and with the 655 ± 25 Ma Rb–Sr date given by Compston and Arriens (1968). Thus the broad geochronological framework of the complex is better established, though details of its evolution remain to be determined.

Sm–Nd data have now been obtained (Table 1) for two additional drillcore samples from the basement of the southern portion of the Perth Basin, enabling this crustal unit to be characterized with more confidence than was possible using the one analysis from Fletcher et al. (1985). Both samples are from the Vasse Shelf, between the Dunsborough and Busselton Faults (Figs 1, 2). GSWA 93867 is a weakly carbonated garnet–biotite metasyenogranite from 568 m in CRA borehole CRCH–1, and GSWA 75497 is a garnet–biotite monzosyenitic flaser gneiss from 200.5 m in Treeton borehole DDH–2. The model ages (T_{DM} = 2018 Ma and 2011 Ma, respectively) agree closely with published data for the Sue 1 drillcore sample (2059 Ma; Table 1), and with data for more northerly parts of the Pinjarra Orogen

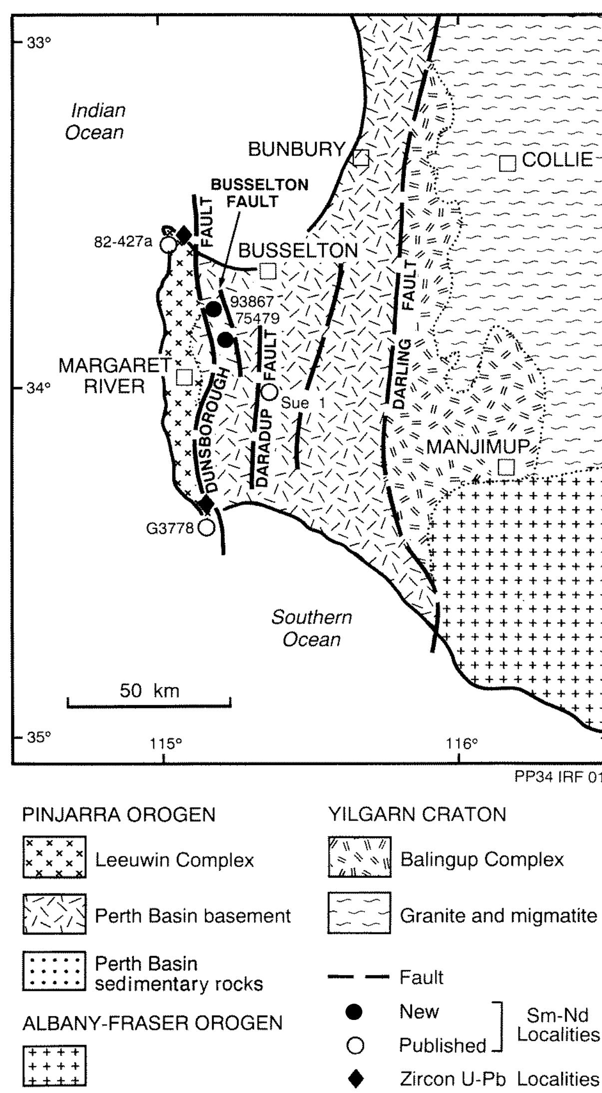

Figure 1. Major tectonic subdivisions of crystalline rocks in southwestern Western Australia (after Myers and Hocking, 1988), showing Sm–Nd and zircon U–Pb samples sites in the southern Pinjarra Orogen (Table 1; McCulloch, 1987; Wilde and Murphy, 1988).

Table 1. Sm–Nd data for felsic samples from the southern portion of the Pinjarra Orogen

Sample	*Sm* (ppm)	*Nd* (ppm)	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$ *(a)*	$T_{CHUR}(b)$ *(Ma)*	$T_{MORB}(c)$ *(Ma)*	$T_{DM}(d)$ *(Ma)*
			Perth Basin basement				
93867	16	88	(f) 0.11169 ± 12	0.511667 ± 10	1705	2079	2018
75497	2	12	0.10234 ± 26	0.511548 ± 10	1727	2067	2011
W1672	(Sue #1; Fletcher et al., 1985)				1797	2110	2059
			Leeuwin Complex				
G3778 (e)	21	145	0.08596 ± 19	0.512072 ± 21	755	1217	1135
82-427a	(Sugarloaf; data from McCulloch, 1987)				584	1185	1083

(a) Normalized to $^{146}Nd/^{144}Nd = 0.7219$ and corresponding to a measured $^{143}Nd/^{144}Nd = 0.512622$ for BCR–000001 (Fletcher et al., 1991)
(b) Using chondritic parameters [0.1967, 0.51262]
(c) Using an assumed linear evolution of depleted mantle from $\varepsilon_{Nd}(3.5\ Ga) = 0$ to $\varepsilon_{Nd}(0) = +10$ (present-day MORB source).
(d) Using the depleting mantle model of de Paolo (1981).
(e) Listed as 'IF–1' by McCulloch (1987).
(f) All error limits pertain to the final two significant digits

T_{CHUR} and T_{MORB} are listed for ease of comparison with some published data for Western Australia and possibly related terranes (e.g. Sri Lanka; Millisenda et al., 1988). T_{DM} is probably a better *estimate of 'crustal residence age'.*

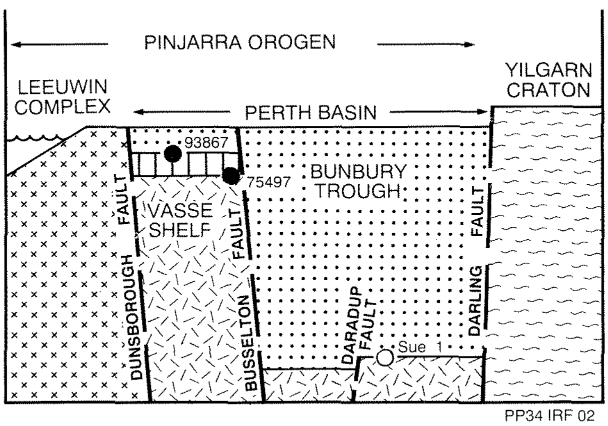

Figure 2. Schematic structural cross section of the study area, showing relative positions of samples from the Perth Basin basement. The Vasse Shelf dips south (projected surface shown with vertical hatching) and the base of the Bunbury Trough dips north. Vertical exaggeration about 10:1 (Legend as for Fig. 1).

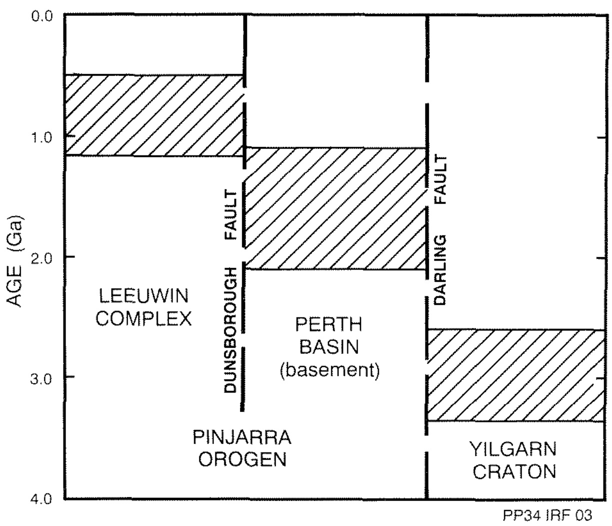

Figure 3. Evolutionary spans of the southwestern Yilgarn Craton and the Pinjarra Orogen, defined by data from as far north as the Northampton Complex. Older age limits are the earliest identified crust-formation ages (T_{DM}); younger limits are the ages of the youngest known major magmatic or metamorphic events.

(Fletcher et al., 1985). The dates are quite distinct from those for the Leeuwin Complex, confirming that the boundary between the Leeuwin Complex and the Perth Basin basement is the Dunsborough Fault tectonic zone rather than the Busselton Fault or the Daradup Fault.

It is clear that in the southwestern extremity of Australia there are extensive terranes of markedly different ages in close juxtaposition (Fig. 3). This may be due, in part, to strike-slip motion along major tectonic zones, particularly the Dunsborough and Darling fault systems (Harris, 1987). However, the great extent of the Pinjarra Orogen and the existence of extensive Proterozoic mobile belts around most of the Yilgarn Craton (McCulloch, 1987) mirror features of the sequential patterns seen in Proterozoic terranes of North America (Bickford, 1988) and argue for lateral growth of continental crust, whether by accretion of younger crustal material or by generation of new crust in continental rifts.

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