Old zircons and the early evolution of the Yilgarn Craton

by

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Several greenstone belts in the Southern Cross Granite–Greenstone Terrane of the Yilgarn Craton (Fig. 1) contain quartz-rich metasedimentary rocks. Recent SHRIMP U–Pb zircon geochronology on quartzites from some of these belts has identified populations of very old (>3.1 Ga) detrital zircons (Nelson, 2000, 2002). Similar results have been obtained from metasedimentary rocks in the Mount Narryer and Jack Hills areas in the Narryer Terrane, and at Windmill Hill in the Jimperding metamorphic belt in the South West Terrane (Froude et al., 1983; Wilde et al., 2001; Kinny, 1990), but no rocks with very old detrital zircons have been identified from either the Murchison or the Eastern Goldfields Granite–Greenstone Terranes.

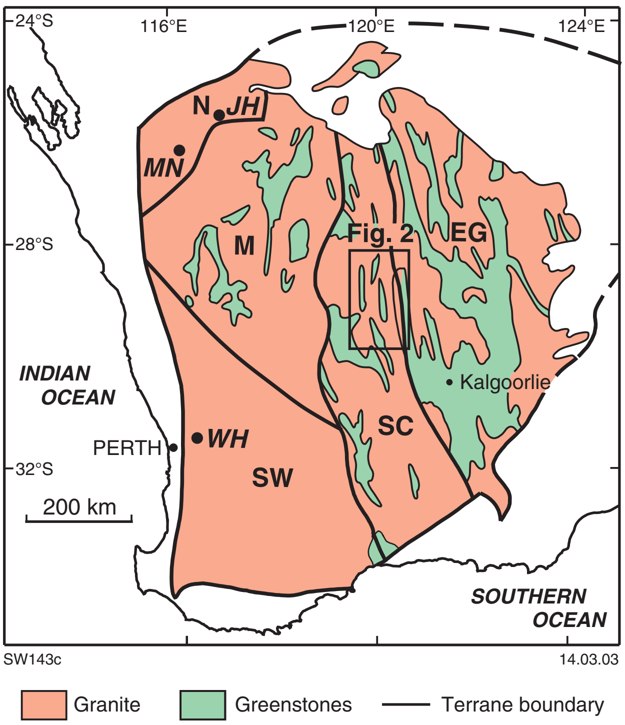

Figure 1. Outline of the Yilgarn Craton showing the major subdivisions: N — Narryer Terrane; SW — South West Terrane; M — Murchison Granite–Greenstone Terrane; SC — Southern Cross Granite–Greenstone Terrane; EG — Eastern Goldfields Granite–Greenstone Terrane. Localities: WH — Windmill Hill; MN — Mount Narryer; JH — Jack Hills

The Southern Cross and Murchison Granite–Greenstone Terranes are similar in character, and typically contain older rocks than those in the Eastern Goldfields Granite–Greenstone Terrane. Zircon geochronology from the Southern Cross and Murchison Granite–Greenstone Terranes indicates that the oldest greenstones were deposited before 2.9 Ga, with episodes of felsic volcanism through to 2.7 Ga (Pidgeon and Wilde, 1990). The major period of granitoid intrusion was after c. 2750 Ma (Wiedenbeck and Watkins, 1993; Nelson, 2000, 2002). In contrast, greenstone deposition in the Eastern Goldfields Granite–Greenstone Terrane took place mainly after c. 2710 Ma, with the main period of granitoid intrusion after c. 2690 Ma (Nelson, 1997). Gneisses in the Narryer Terrane are substantially older than any igneous rocks that have been dated elsewhere in the Yilgarn Craton, with components ranging in age from c. 3730 Ma to c. 3300 Ma (Kinny et al., 1988). Although containing metasedimentary units with very old detrital zircon populations, no greenstones older than 2.7 Ga have been identified in the South West Terrane, and there is no evidence of granitoids older than c. 3250 Ma (Wilde, 2001).

The stratigraphy of the Southern Cross Granite–Greenstone Terrane greenstones is poorly constrained, with a probably 3.0 Ga lower succession unconformably overlain by a locally developed c. 2730 Ma upper succession. Both were intruded by monzogranite predominantly between c. 2740 and c. 2650 Ma. The lower succession, the major component of most greenstone belts in the region, is dominated by mafic intrusive and extrusive rocks, but contains abundant banded iron-formation at some stratigraphic levels, local komatiite and, in some greenstone belts, quartz-rich metasedimentary rocks including quartzite, conglomerate, and quartz–mica schist. The upper succession consists of felsic volcanic and clastic sedimentary rocks. The poor exposure and lack of suitable horizons for zircon geochronology have precluded correlation of the lower greenstone succession between greenstone belts.

Although locally present to the south, the greatest thickness of quartzite and associated quartz-rich

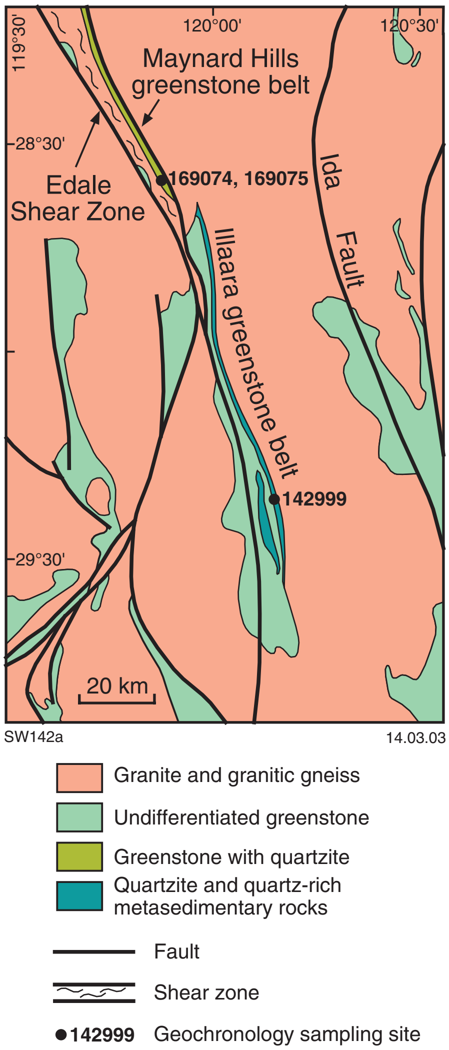

Figure 2. Geology of the Illaara – Maynard Hills region, showing geochronology sample locations

metasedimentary rocks in the Southern Cross Granite–Greenstone Terrane is found in the Illaara and Maynard Hills greenstone belts (Fig. 2). Quartz-rich metasedimentary rocks in the Illaara greenstone belt, although commonly deformed, are preserved at two levels at least. Those in the Maynard Hills greenstone belt are strongly deformed and dismembered by the Edale Shear Zone, but probably represent the northern extension of the lowermost metasedimentary unit of the Illaara greenstone belt.

Primary textural and sedimentological features in the quartzite of the Illaara and Maynard Hills greenstone belts are poorly preserved due to the effects of deformation and recrystallization. Quartzite samples were taken from two localities: one from the eastern side of the south-central part of the Illaara greenstone belt, and two from the southern end of the Maynard Hills greenstone belt (Fig. 2). A range of ages was determined, with most falling between 3.7 and 3.3 Ga (Nelson, 2000, 2002), similar to gneisses of the Narryer Terrane. The youngest age of c. 3131 Ma was obtained on a zircon from the Maynard Hills greenstone belt; whereas the oldest age determination, also from the Maynard Hills greenstone belt, was c. 4350 Ma. This latter age is the among the oldest ages determined for a terrestrial zircon.

Rare xenocrystic zircons older than 3.0 Ga in igneous rocks, and granitoid geochemistry that requires at least a two-stage melting process, suggest the presence of older sialic crust in the Yilgarn Craton. However, no such material has been identified in the Murchison, Southern Cross, or Eastern Goldfields Granite–Greenstone Terranes. Thus, with the present-day configuration of the Yilgarn Craton, the nearest preserved possible provenance for the Illaara and Maynard Hills quartzites is more than 300 km away.

Kinny (1990) proposed that the similarity of the age profiles of detrital zircon populations from metasedimentary rocks in the Jimperding metamorphic belt in the South West Terrane to those in the Mount Narryer and Jack Hills areas in the Narryer Terrane suggests a common provenance. He further suggested that the gneisses of the Narryer Terrane may be a remnant of this older continental mass.

The age profiles of detrital zircon populations from quartzites from the Illaara and Maynard Hills greenstone belts in the Southern Cross Granite–Greenstone Terrane indicate a common provenance with metasedimentary rocks of the Narryer and South West Terranes. Also supporting a common source of detrital zircons for the Narryer and Southern Cross metasedimentary rocks is the c. 4350 Ma age obtained from the Maynard Hills greenstone belt. The only other greater than 4.1 Ga zircons that have previously been identified are detrital zircons from Mount Narryer and Jack Hills in the Narryer Terrane (Wilde et al., 2001). This wide distribution of quartz-rich metasedimentary rocks, and the lack of any ancient detrital zircons in rocks of the Murchison Granite–Greenstone Terrane, suggests that either the continental precursor to the Yilgarn Craton that provided the provenance for these rocks was much smaller than the present-day central and western Yilgarn, or that a widespread, old continental mass has been largely reworked. The source of the very old (>c. 3730 Ma) detrital zircons in the Southern Cross Granite–Greenstone and Narryer Terranes remains unclear as no rocks greater than c. 4030 Ma (Bowring and Williams, 1999) have been identified on Earth.

As no greenstones that are older than the youngest detrital zircons from these rocks have been identified in the Murchison Granite–Greenstone, Southern Cross Granite–Greenstone, or South West Terranes, the early clastic sedimentary formations around the western two-thirds of the Yilgarn Craton may have been shallow-marine shelf deposits adjacent to a continental mass of which the Narryer Terrane is a remnant. This suggests that the areas now occupied by the Southern Cross Granite–Greenstone, Murchison Granite–Greenstone, South West, and Narryer Terranes may have been a single entity prior to the deposition of quartz-rich metasedimentary rocks at 3.1 Ga.

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