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Early meteoric fluid flow in high-grade, low-^{18}O gneisses from the Mallee Bore area, northern Harts Range, central Australia

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Abstract: Granulite-facies ortho- and paragneisses from the Mallee Bore area, central Australia are depleted in ^{18}O by up to 10‰. The zone of ^{18}O depletion is elongate, not coincident with any lithological or structural feature, and covers an area of approximately 9 km × 3 km. Within this zone, average $\delta^{18}O$ values of paragneisses and orthogneisses are *c*. 4.6‰ and *c*. 4.1‰ respectively, and locally are as low as 2.7‰ and 2.4‰, respectively. The lowering of $\delta^{18}O$ values probably occurred due to isotopic exchange between the rocks and a surficial fluid at high temperatures. The preservation of high-temperature mineral oxygen isotope fractionations and the lack of gross retrogression of the Mallee Bore rocks, indicates that fluid flow after regional metamorphism was negligible. Furthermore, the difficulties associated with downward circulation of surface-derived fluids to depths in excess of 25 km, as well as the lack of wholesale melting in the rocks, suggest that fluid flow occurred prior to the peak of granulite-facies regional metamorphism. Hence, the ^{18}O depletion observed at Mallee Bore most likely occurred during early contact metamorphism, or during the prograde stages of regional metamorphism. The preservation of low $\delta^{18}O$ values suggests that there was little pervasive fluid flow during or subsequent to regional metamorphism.

Keywords: Arunta Block, fluids, stable isotopes, granulite facies.

Documenting metamorphic fluid flow is important because fluids, if present in sufficient volumes, can transport heat and matter, control mineral stabilities, and affect crustal rheology. In regional or contact metamorphic environments whole rock geochemistry, mineralogy, and stable isotope ratios may be used to characterize fluid flow. Granulite-facies regional metamorphism often occurs under fluid-absent conditions (e.g. Cartwright 1988; Valley *et al.* 1990). However, granulite terrains may record evidence of fluid-flow before and/or after the metamorphic peak. For example, some granulite terrains experienced fluid-flow during early contact metamorphism (e.g Adirondacks, Valley *et al.* 1990; Reynolds Range, Buick *et al.* 1994; Buick & Cartwright 1995; Buick & Cartwright 1996; Cartwright *et al.* 1996). In addition, they may also record episodes of fluid flow during cooling that are commonly related to crystallization of partial melts (e.g. Cartwright 1988; Waters 1988; Cartwright & Buick 1995). Because there may be superposition of several fluid flow events both before and after regional metamorphism, the fluid-flow history in granulite terrains is often not easily resolved, especially in terrains where low grade precursors are not preserved.

In this paper, petrology and stable isotope geochemistry are used to constrain fluid-rock interaction in the Mallee Bore area of the Arunta Inlier, central Australia. We show that an area that is currently around 9 km × 3 km was infiltrated by surficial fluids prior to the peak of regional metamorphism, probably during early contact metamorphism at shallow crustal levels. The preservation of stable isotope ratios attributed to this early fluid-flow event suggests that the later regional metamorphism involved little pervasive fluid flow.

Geological setting

The Mallee Bore area is part of the Harts Range in the east of the central province of the Arunta Inlier, a major mid-Proterozoic mobile belt covering approximately 200 000 km^2 in central Australia (Fig. 1). The Harts Range contains rocks divided into two upper-amphibolite-facies complexes, the structurally superior Harts Range Complex and the underlying Entia Gneiss Complex. The Harts Range complex comprises the Irindina supracrustals, the Harts Range metaigneous complex, as well as subsidiary pelitic, semi-pelitic, and carbonate rock units (Ding & James 1985). The underlying Entia Gneiss Complex consists of a supracrustal assemblage including interlayered amphibolites, calc-silicate rocks, carbonates, pelites and other metasedimentary rocks (Arnold *et al.* 1995). Rocks in the Mallee Bore area have been assigned to the Harts Range Complex (Miller *et al.* 1997). These two complexes were juxtaposed during crustal extension and are now separated by a major, low-angle mylonite zone, termed the Harts Range Detachment Zone (Ding & James 1985; James & Ding 1988; Oliver *et al.* 1988; Foden *et al.* 1995). The Bruna Granite Gneiss, which intrudes the Harts Range Detachment Zone, has been dated at *c*. 1745 Ma by conventional U–Pb bulk zircon methods (Cooper *et al.* 1988). This suggests that both the Harts Range Complex and the Entia Gneiss Complex were formed prior to this date, although more recent geochronological work in the Harts Range suggests that many structural features may be meso-Proterozoic or younger (e.g. Foden *et al.* 1995; Dunlap *et al.* 1996).

Local geology

The Mallee Bore area is made up of a sequence of interlayered metabasic rocks (the Mallee Bore orthogneisses) and pelitic and semi-pelitic metasediments (the Mt Riddoch paragneisses) (Fig. 2) that underwent regional metamorphism at granulite-facies conditions of 820–850°C and 8–11 kbar, probably during the late Strangways orogeny at 1730 Ma (Miller *et al.* 1997).