Granulite facies metamorphism in the Mallee Bore area, northern Harts Range: implications for the thermal evolution of the eastern Arunta Inlier, central Australia

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ABSTRACT The Mallee Bore area in the northern Harts Range of central Australia underwent high-temperature, medium- to high-pressure granulite facies metamorphism. Individual geothermometers and geobarometers and average *P–T* calculations using the program Thermocalc suggest that peak metamorphic conditions were 705–810 °C and 8–12 kbar. Partial melting of both metasedimentary and meta-igneous rocks, forming garnet-bearing restites, occurred under peak metamorphic conditions. Comparison with partial melting experiments suggests that vapour-absent melting in metabasic and metapelitic rocks with compositions close to those of rocks in the Mallee Bore area occurs at 800–875 °C and >9–10 kbar. The lower temperatures obtained from geothermometry imply that mineral compositions were reset during cooling. Following the metamorphic peak, the rocks underwent local mylonitization at 680–730 °C and 5.8–7.7 kbar. After mylonitization ceased, garnet retrogressed locally to biotite, which was probably caused by fluids exsolving from crystallizing melts. These three events are interpreted as different stages of a single, continuous, clockwise *P–T* path. The metamorphism at Mallee Bore probably occurred during the 1745–1730 Ma Late Strangways Orogeny, and the area escaped significant crustal reworking during the Anmatjira and Alice Springs events that locally reached amphibolite facies conditions elsewhere in the Harts Ranges.

Key words: granulite metamorphism; *P–T* path; partial melting; Harts Range; Arunta Inlier.

INTRODUCTION

Pressure-temperature-time (*P–T–t*) paths are important indicators of tectonic and geodynamic processes in the middle to lower crust (e.g. England & Thompson, 1984). However, the construction and interpretation of metamorphic *P–T–t* paths, especially in older, high-grade, multiply metamorphosed terranes, is complicated by a number of factors, including: (1) the reliance upon interpretation of mineral reaction textures that may be ambiguous (e.g. Vernon, 1996); (2) the possible superposition of temporally distinct metamorphic events (e.g. Hand *et al.*, 1994); and (3) the difficulty associated with estimating pressures and temperatures from rocks that have cooled slowly from high temperatures (up to 1000 °C), due to the fact that mineral compositions may re-equilibrate during cooling (Frost & Chacko, 1989; Harley, 1989). Diffusional re-equilibration of mineral compositions during cooling, particularly in granulite facies rocks, and its effect on calculated *P–T* paths have been the focus of numerous studies (e.g. Harley, 1989; Selverstone & Chamberlain, 1990; Spear & Florence, 1992), which concluded that peak metamorphic temperatures are commonly not preserved. Although some attempts have been made to correct for Fe–Mg exchange during cooling (e.g. Fitzsimons & Harley, 1994; Begin & Pattison, 1994), using the results of dehydration-melting experiments, particularly in rocks of mafic composition (e.g. Rushmer, 1991; Wolf & Wyllie, 1994; Patiño Douce & Beard, 1995) may potentially provide as good an estimate of metamorphic *P–T* conditions as geothermometry and geobarometry in granulite terranes, provided that appropriate melting reactions can be identified.

In this paper we describe the Proterozoic metamorphic evolution of the hitherto unstudied Mallee Bore area on the northern margin of the Harts Range (Fig. 1), and identify three phases of metamorphism and/or deformation on the basis of geothermobarometry, mineral assemblages and mineral textures. The *P–T* conditions calculated from geothermometry and geobarometry are compared with the experimentally determined pressures and temperatures of melting reactions (e.g. Rushmer, 1991; Wolf & Wyllie, 1994; Patiño Douce & Beard, 1995). We propose that the three metamorphic episodes identified are part of a single *P–T–t* path and do not represent discrete or short-lived metamorphic pulses, as has been suggested elsewhere in the Harts Range (e.g. Arnold *et al.*, 1995). Our results suggest that the main metamorphic event