Mid crustal granulite facies metamorphism in the Reynolds Range, central Australia: physical conditions, duration and potential mechanisms

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ABSTRACT

The transient advection of heat due to magma ascent is often the governing paradigm for low-pressure, high-temperature (LPHT) metamorphism. However, the origins of metamorphism (~750 – 800 °C and 4 – 5 kbars) in the Reynolds Range region of the central Arunta Province, Arunta Inlier, central Australia, remain contentious for two reasons: (1) The causative mechanism for high geothermal gradient metamorphism is not well understood; and (2) elevated temperatures appear to be sustained for a prolonged period, ~30 Myr. In situ LA-ICPMS monazite U-Pb geochronology coupled with metamorphic phase equilibria modelling provide evidence for regional-scale high-temperature metamorphism in the Arunta Inlier during the early Mesoproterozoic (ca. 1590 Ma). Metapelitic granulites from the eastern Reynolds Range contain garnet + cordierite + biotite + plagioclase + K-feldpsar + quartz + ilmenite bearing assemblages that formed at around 840 °C and 7 kbars, with the occurrence of fine grained sillimanite at 650 °C and 3 kbars on a clockwise pressure-temperature evolution. In the Mount Boothby north region metapelitic granulites with biotite + K-feldspar + ilmenite + quartz + cordierite + garnet bearing assemblages formed at around 830 °C and 5 kbars, with the occurrence of fine-medium grained andalusite at 630 °C and 3 kbars on a clockwise pressure-temperature evolution. In situ U-Pb geochronology from monazite hosted within garnet in this region yield an age of 1573 ± 11 Ma, with monazite in retrograde biotite recording ages of 1543 ± 10 Ma, suggesting the minimum duration of granulite-facies metamorphism in this region in the order of 30 M.y. This study estimates the cooling rate to be ~4 °C Myr^{-1} based on the differences in peak temperature modelled in P-T pseudosections (~830 °C) with temperatures recorded in the garnet cores obtained from theromobarometry (~700 °C), and the difference in ages obtained from monazites in different textural locations (~30 M.y). The average heat production (recalculated at 1580 Ma) of granitic gneisses, metasediments are 11.04 and 5.71 μWm^{-3}, suggesting the burial of an enriched U- and Th- layer may provide a mechanism for long-lived, high geothermal gradient metamorphism rather than emplacement of magmatism at this time.

Keywords: granulite-facies; in situ monazite geochronology; P-T pseudosection; slow cooling; diffusion modelling.