Petrogenesis of High Heat Producing Granite: Implication for Mt Painter Province, South Australia

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Abstract

Mesoproterozoic granites and associated rocks from the Mt Painter Province, Curnamona Craton are high heat producing (HHP) granites; that they have heat production values greater than 5 μWm^{-3}. The HHP granites form part of a coeval suite with mafic and felsic volcanic rocks including the Pepegoona Volcanic, Mt Neill, Box Bore, Terrapinna, Wattleowie and Yerila Granites, microgranular enclaves and mafic dykes that all yield U-Pb zircon LA-ICPMS crystallization ages ranging from ~1603 to 1504 Ma.

The HHP granites are equigranular to porphyritic, fine-grained to coarse-grained and perthitic with K-feldspar megacrystic phenocrysts. They typically consist of amphibole, clinopyroxene, plagioclase, biotite, ilmenite, magnetite, quartz, apatite, sphene, zircon, fluorite and allanite. Fractional crystallization of accessory minerals led to the observed variations in the trace element concentrations in the granites. The mafic and felsic rocks have high Fe# and enriched in incompatible elements, specifically U, Th, Zr, Y, Ce and REEs, and are low in Sr that are classified as A-type. The Yerila Granite and it's enclave are extremely enriched in U and Th, which are found in abundant allanite, zircon and sphene, and were concentrated in these rocks by fractional crystallization and accumulation. The other felsic units form by a mixing of mafic and felsic magmas and a lesser degree of fractional crystallization. The HHP rocks have εNd values ranging between -3 and +1 and εHf values mainly ranging from -2 and +4. Pb isotope compositions in K-feldspars yield an isochron age of 1746 Ma.

The HHP granitic and associated rocks were derived from fractional crystallization of crustal-contaminated mantle-derived magmas at emplacement levels with composition equivalent to the mafic dykes. This parental magma composition is assumed to be consistent with a mixture of mantle-derived magma with a ~20% crustal component. To explain these observations, a model is presented that the crustal-contaminated magmas, which were enriched in incompatible elements, were formed by a combination of partial melting of the lower crust and mantle-derived mafic magma. Mafic sills that emplaced at the mantle-crust boundary during extension tectonism at *ca.* 1.76 Ga caused partial melting of the crust. During the early Mesoproterozoic (1603-1504 Ma), crustal

thickening and extensional collapse or extension preceding thickening in a continental back-arc setting or mantle plume led to mantle upwelling and the generation of melt. There is evidence for mixing between evolved fractionated felsic magmas and the mafic magmas suggested multiple inputs of mafic magma. This mixing of felsic and mafic magmas occurred by convection before the felsic suites ascent to the near surface in low fO_2, fH_2O and high temperature environments.

Comparing the results of this study with previous studies on HHP granites from other Australian Terranes suggests that they formed coevally with the mafic rocks and have crystallization ages ranging from ~1.82 to 1.49 Ga. A mixture of mantle-derived magma and crustal components are inferred as the main sources generating the HHP magmatic rocks. These granites are inferred to have been emplaced in intraplate or back arc settings by rifting or crustal extension.

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