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Hot Rocks: The Flinders Ranges Crystalline Basement

Joe Hiess

Research School of Earth Sciences,
The Australian National University,
0200 Canberra, Australia
Email: joe.hiess@anu.edu.au

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Extended Abstract

The cratonic crystalline basement of the Mount Painter Province consists of Paleoproterozoic gneisses and metasediments intruded by A-type Mesoproterozoic, and I- and S-type Paleozoic granites (Coats and Blissett, 1971b; Teale, 1993; Paul et al., 2000), locally altered to gneiss and schist (Elburg et al., 2003). The basement is exposed over ca. 780km^2 and forms the northernmost foundation to the Adelaide Fold Belt System (Sandiford et al., 1998a).

The Mount Painter Province has the youngest and most heat productive Proterozoic granites within the regional South Australian heat flow anomaly (Neumann et al., 2000). Heat production ranges from 1 to 65 Wm^{-3} and averages at ca. 16 Wm^{-3}, more than three times that of the global upper crust average (Sandiford et al., 1998a; Neumann et al., 2000; McLaren, 2001; McLaren et al., 2002b). These crustal sources may contribute ca. 100mWm^{-2} to the present day regional surface heat flow, of approximately 126mWm^{-2} (Cull, 1982; Neumann et al., 2000), with thermal gradients remaining elevated through much of the Paleozoic (McLaren et al., 2002b).

Heat production anomalies in the near surface crust are intimately linked with granite formation (Neumann et al., 2000; McLaren et al., 2002a). They are associated by a unique enrichment of radiogenic U, Th and K (Neumann et al., 2000; McLaren et al., 2002a). Average geochemical concentrations and heat production values for selected units of the Mount Painter Province is presented in Sandiford et al. (1998a) and Neumann et al. (2000). Although U and Th are present in extreme concentrations, Th/U ratios are dominantly 3-5, suggesting enrichment is a primary magmatic signature (Neumann et al., 2000).

Geochemical characteristics reflect source composition and petrogenetic processes, as felsic magmas shape the vertical distribution of radiogenic elements in the crust (Neumann et al., 2000). Heat producing granites have relatively high initial eNd values (-3.2 to -0.5) showing limited variation (Neumann et al., 2000). Almost all Proterozoic granites are depleted in Sr but not Y, reflecting derivation from moderately shallow sources stable for plagioclase, but not garnet (Wyborn et al., 1992). These granites have probably experienced a significant crustal recycling prehistory rather than formation directly from the mantle (McLaren et al., 2002a). This is supported by the negative eNd values (McCulloch, 1987; Wyborn et al., 1992) and similar isotopic signatures to the associated basement rocks. Melts containing a small enriched crustal component would have required extreme fractionation to reconcile such high eNd, U, Th and K concentrations (Neumann et al., 2000). Anatexis of a source region of considerably greater volume than the underlying crust and mantle would be required to provide an alternative reservoir for radiogenic elements (Rudnick and Fountain, 1995; Neumann et al., 2000).

The effect of high heat producing granites on thermal and structural events during the Dalmatian Orogeny (ca. 490-515 Ma) has been proposed (Sandiford et al., 1998a; Paul et al., 2000; McLaren et al., 2002b), as has mechanism for shallow enrichment as a result of limited denudation (ca. 10-15km) since the Proterozoic (McLaren et al., 2002a). The timing of the Dalmarian Orogeny has been constrained by intrusion of synand post-deformational granites, leucogranites, pegmatites and associated hyrothermal systems (Elburg et al., 2003).

The I and S-type British Empire Granite (Sandiford et al., 1998a) formed 450 Ma (McLaren, pers. comm.) and is not high heat producing. I-type magmas (eNd -11 to -3) may have formed by melting of preexisting igneous material or a mixing of crustal and mantle sources. S-type magmas (eNd -12 to -14) suggest a major role of crustal reworking with materials more similar to Proterozoic metasediments than the A-type granites, that would require significant fractionation between elements (Elburg et al., 2003). Small volumes of leucogranite and pegmatite also have low eNd (-12 to -14) again sourced from a crustal protolith (Elburg et al., 2003). Trace element patterns for major suites are compared in Figure 9 in Elburg et al. (2003). There is no evidence of advective heat input from the mantle at this structural level as indicated elsewhere in the South Adelaide Fold Belt (Turner et al., 1992; Foden et al., 2002). The Proterozoic magmatic activity has been described as either a protracted cooling history (McLaren et al., 2002a) or successive pulsing (Elburg et al., 2003).

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