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A high-resolution, calibrated airborne radiometric dataset applied to the estimation of crustal heat production in the Archaean northern Pilbara Craton, Western Australia

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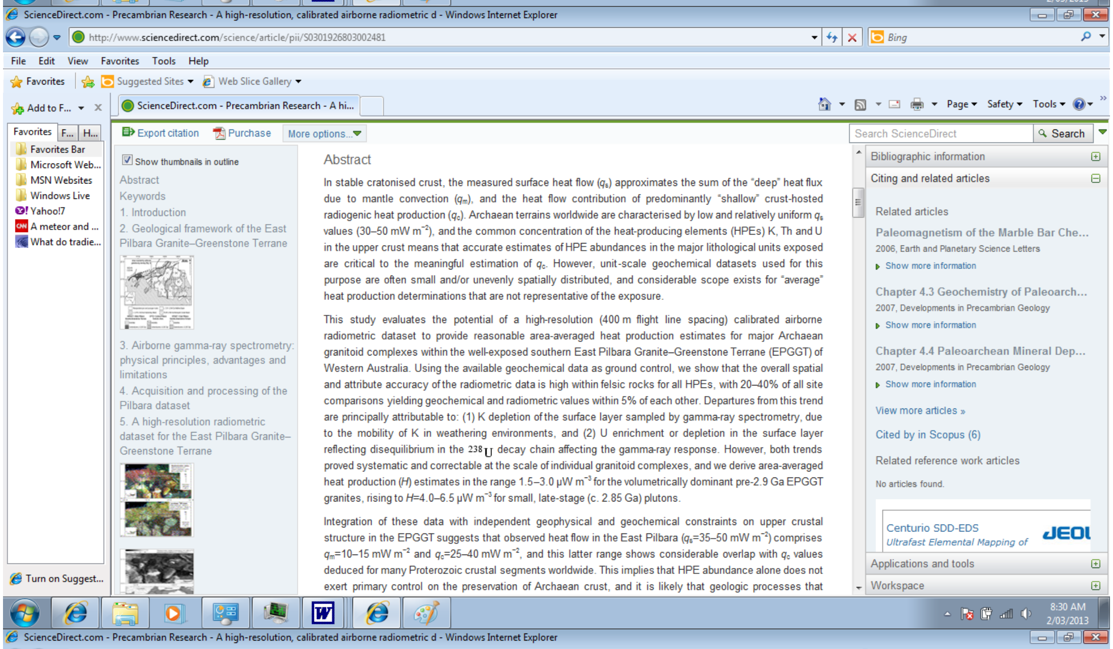
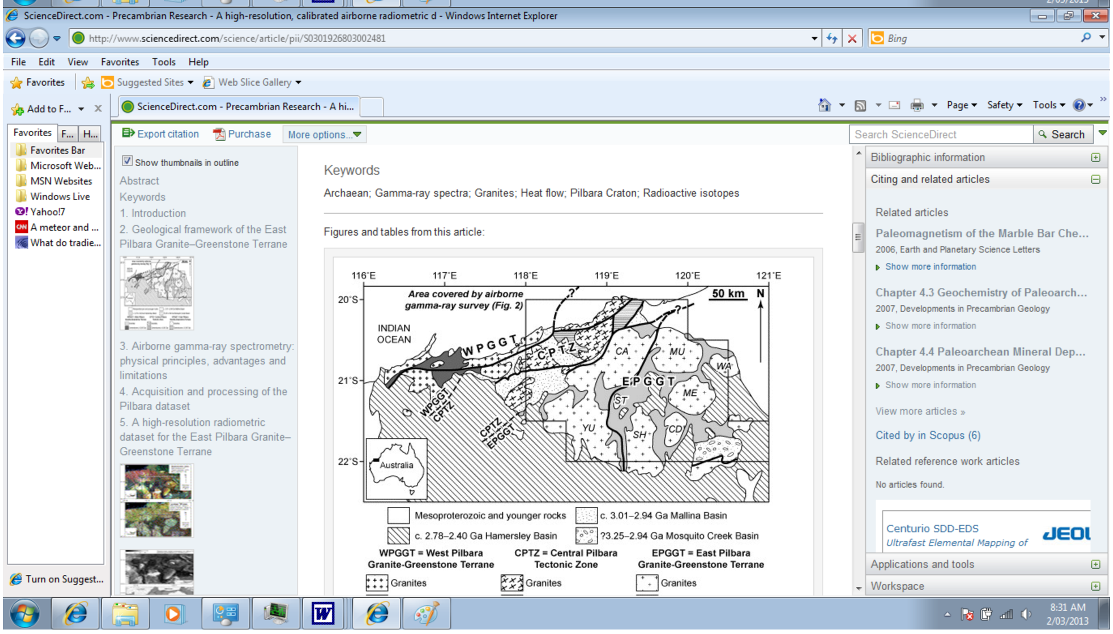


Abstract

In stable cratonised crust, the measured surface heat flow (q_s) approximates the sum of the "deep" heat flux due to mantle convection (q_m), and the heat flow contribution of predominantly "shallow" crust-hosted radiogenic heat production (q_c). Archaean terrains worldwide are characterised by low and relatively uniform q_s values (30–50 mW m^{-2}), and the common concentration of the heat-producing elements (HPEs) K, Th and U in the upper crust means that accurate estimates of HPE abundances in the major lithological units exposed are critical to the meaningful estimation of q_c. However, unit-scale geochemical datasets used for this purpose are often small and/or unevenly spatially distributed, and considerable scope exists for "average" heat production determinations that are not representative of the exposure.

This study evaluates the potential of a high-resolution (400 m flight line spacing) calibrated airborne radiometric dataset to provide reasonable area-averaged heat production estimates for major Archaean granitoid complexes within the well-exposed southern East Pilbara Granite–Greenstone Terrane (EPGGT) of Western Australia. Using the available geochemical data as ground control, we show that the overall spatial and attribute accuracy of the radiometric data is high within felsic rocks for all HPEs, with 20–40% of all site comparisons yielding geochemical and radiometric values within 5% of each other. Departures from this trend are principally attributable to: (1) K depletion of the surface layer sampled by gamma-ray spectrometry, due to the mobility of K in weathering environments, and (2) U enrichment or depletion in the surface layer reflecting disequilibrium in the ^{238}U decay chain affecting the gamma-ray response. However, both trends proved systematic and correctable at the scale of individual granitoid complexes, and we derive area-averaged heat production (H) estimates in the range 1.5–3.0 μW m^{-3} for the volumetrically dominant pre-2.9 Ga EPGGT granites, rising to H=4.0–6.5 μW m^{-3} for small, late-stage (c. 2.85 Ga) plutons.

Integration of these data with independent geophysical and geochemical constraints on upper crustal structure in the EPGGT suggests that observed heat flow in the East Pilbara (q_s=35–50 mW m^{-2}) comprises q_m=10–15 mW m^{-2} and q_c=25–40 mW m^{-2}, and this latter range shows considerable overlap with q_c values deduced for many Proterozoic crustal segments worldwide. This implies that HPE abundance alone does not exert primary control on the preservation of Archaean crust, and it is likely that geologic processes that



Keywords

Archaean; Gamma-ray spectra; Granites; Heat flow; Pilbara Craton; Radioactive isotopes

Figures and tables from this article: