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Mineral inclusion thermobarometry in >4 Ga Jack Hills zircons provides constraints on Hadean geodynamics

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Detrital zircons from the Jack Hills of Western Australia provide an important record of terrestrial conditions during the Hadean Eon (ca. >4 Ga). Mineral inclusions captured in these ancient zircons add an extra dimension to our knowledge of Hadean Earth. The inclusion population is dominated by the presence of quartz and muscovite, most apparently primary to these igneous zircons. Several lines of evidence support this view and argue against widespread exchange between most of these inclusions and their environment: (i) lack of association with cracks; (ii) magmatic crystal forms; (iii) absence of exchange with fuchsitic (Cr-rich) micas in the host conglomerate; and (iv) the heterogeneity in Sipfu values. We report new data on Ti concentration in quartz inclusions within Hadean zircons. The factor-of-10 difference in Ti content among included quartz grains is evidence against chemical communication between the host quartzite and inclusions, since the Jack Hills quartzite contains rutile which was mobile during metamorphism at ca. 2.5 Ga. Using the recently calibrated Ti-in-quartz thermobarometer yields a narrow range of pressure (20+/-2 kbar) for the three samples. This is in broad accord with the pressure range estimated for included muscovites with ˜3.4 Sipfu (18+/-9 kbar). Taken together, the Hadean zircon inclusion assemblages yield estimates of magmatic P-T conditions from 5 to ca. 20 kbar at 700;/-40 C further supporting their formation under geotherms of ?60 C/km thus implying conductive near-surface heat flow of ca. 20 to 80 mW/m2. Of all formational environments that satisfy the spectrum of geochemical constraints available and the inference of melt generation under suppressed heat flow, the most plausible appears to be partial melting of both juvenile and mature continental sediment via continuous underthrusting beneath a stable upper plate. We postulate that this melting could occur two different ways: fluxed melting of underthust sedimentary material, or fluxed melting of the upper plate due to plate dehydration or degassing of hydrous magma in the underthrust environment.

Keywords: zircon, Hadean, inclusion, thermobarometry, U?Pb age, Jack Hills