Crustal heat generation rates in the North China Khondalite Belt high to ultra-high-temperature metamorphic rock system

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The widespread occurrence of high to ultra-high temperature (HT-UHT) metamorphism in continental crust has been widely documented worldwide. However, there has been ongoing debate on the heat sources responsible for generating these HT-UHT conditions.

Generating HT-UHT temperatures is thought to require either singularly, or in combination, long-lived crustal thickening (e.g. orogenic systems) with high radioactive heat production and low erosion rates, or large supplies of heat from the mantle either through conduction within thinned lithosphere (e.g. back-arc) or by advective heating linked to large-scale mantle-derived magma's. Distinction between these two major thermal sources can made on the crustal heat generation rates and timescales of the HT-UHT metamorphism and the volumes of externally derived high-temperatures magmas. Therefore, a detailed understanding of the terrain-scale heat generation rates, and the metamorphic P-T-t path inferred from the integration of petrochronology and phase equilibria modelling can provide important information.

The Paleoproterozoic Khondalite (metasedimentary) rock system in the North China Craton is thought to represent a typical Paleoproterozoic HT metamorphic belt with local areas reaching UHT conditions and it has been extensively studied. In terms of the thermal drivers, most workers suggest advective heating from the emplacement of mantle related mafic magma, although the apparent volume of clearly-mantle derived magma appears generally insufficient to account for the regional extent of HT-UHT conditions.

To better understand the mechanisms leading the HT-UHT conditions, we need (1) regional-scale measurements of in-situ heat producing elements and (2) a better understanding of the duration of HT-UHT conditions on a regional scale. To better characterise in-situ thermal sources we have determined heat generation rates using quantitative in-field gamma ray spectrometer (GRS) analysis. Volume averaging of rock types indicates terrain-scale U-Th concentrations would have
generated around 3 mWm$^{-3}$ at the time of metamorphism. Given that U-Th would have been lost from the metamorphic system during extraction of high-temperature crustal melts, simple modelling shows the crustal U-Th concentrations would have contributed substantially to the generation of the high-temperature thermal regime. Furthermore, a preliminary compilation of concordant zircon and monazite metamorphic ages from published literature shows a range of ca. 1950-1850 Ma in both western and eastern Khondalite Belt, suggesting possible long-lived metamorphism. Therefore, we argue that the role of the mantle derived advective heat in generating the UHT regime in the North China Khondalite Belt may have been overestimated.

**Key words:** heat generation, HT-UHT metamorphism, Khondalite Belt, North China Craton