

Contrasting mechanisms of Ultrahigh-temperature (UHT) Metamorphism in the Khondalite Belt, North China Craton

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Ultrahigh-temperature (UHT) metamorphism is the most extreme thermal condition occurring within the continental crust, yet its genetic mechanism remains enigmatic. Currently, two main hypotheses have been proposed regarding the origin of UHT metamorphism: one suggests that it is driven by heat released from the decay of radiogenic elements (U, Th, K) within thickened crust, while the other emphasizes the thermal input from asthenospheric mantle upwelling [1]. The Khondalite Belt, North China Craton is a Paleoproterozoic collisional orogenic belt, where previous studies have demonstrated widespread exposure of ~1.93–1.85 Ga UHT granulites. However, unlike the eastern segment, where mafic magmatism roughly coeval with UHT metamorphism has been reported [2], no such contemporaneous mafic magmatism has been identified in the western segment. This makes the Khondalite Belt an ideal region for investigating different genetic mechanisms of UHT metamorphism. Additionally, compared to the nearly coeval S-type granites in the eastern segment (~1.93–1.92 Ga), the S-type granites in the western segment formed earlier (2.0–1.95 Ga).

In this study, we systematically analyzed the heat production rates of the major lithologies in both segments of the Khondalite Belt, namely the Khondalite Series and S-type granites. Our results indicate that the rocks in the western segment exhibit significantly higher heat production rates than those in the eastern segment. Specifically, the heat production rates of the Khondalite Series and S-type granites in the western segment are $3.01 \pm 2.34 \mu\text{W}/\text{m}^3$ ($n=28$) and 4.21 ± 3.38 ($n=114$) $\mu\text{W}/\text{m}^3$, respectively, whereas in the eastern segment, they are $1.83 \pm 0.73 \mu\text{W}/\text{m}^3$ ($n=29$) and $1.67 \pm 0.96 \mu\text{W}/\text{m}^3$ ($n=104$), respectively. Based on one-dimensional thermal modeling, we infer that UHT metamorphism in the western segment was primarily driven by radiogenic heat from the thickened crust. Furthermore, the higher radiogenic heat production of the Khondalite Series in the western segment facilitated the earlier formation of S-type granite compared to the S-type granite in the eastern segment caused by mafic magma underplating during later extension period.

[1] Jiao et al. (2023), *Nature Reviews Earth & Environment* 4, 298-318; [2] Huang et al. (2019), *Journal of Geophysical Research: Solid Earth* 124, 11218-11231.