Thermal gap between UH*T* granulite and surrounding pelitic gneiss from Rundvågshetta in the Lützow-Holm Complex, East Antarctica

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Revealing the formation mechanisms of ultrahigh-temperature (UH*T*) metamorphic rocks is essential to understand the deep crustal processes associated with supercontinent formation events [e.g., 1]. The peak UH*T* metamorphic conditions and subsequent near-isothermal decompressional *P*-*T* paths of UH*T* granulites from Rundvågshetta (Lützow-Holm Complex, East Antarctica) have been well constrained by several previous studies [e.g., 2]. On the other hand, only a few studies have constrained the *P*-*T* conditions of other lithologies occurring in Rundvågshetta, which lack diagnostic mineral assemblages for UH*T* [e.g., 3]. The *P*-*T* evolutions of other lithologies, especially those of pelitic gneisses surrounding the UH*T* granulite layers or lenses, are indispensable to understand the formation mechanisms of UH*T* metamorphic rocks.

Recently, a number of trace element geothermometers have been proposed [e.g., 4] and applied to UH*T* metamorphic rocks [e.g., 5]. The trace element geothermometers have potentials to newly detect UH*T* metamorphic rocks that do not contain diagnostic mineral assemblages for UH*T* [6].

By applying the Zr-in-rutile geothermometer [4] to rutile inclusions in garnet enclosing Al_2SiO_5 minerals and nanogranite inclusions (NIs) [7], this study revealed the detailed *P*-*T*-melting histories involving early high-*P* stages of a UH*T* granulite and a surrounding pelitic gneiss from Rundvågshetta. Chemical zoning of garnet in terms of P was utilized to indicate isochronous surface. As a result, thermal gap of ~ 100 °C was detected between these two lithologies.

In the case of the pelitic gneiss without diagnostic mineral assemblages for UH*T*, the P-poor cores of garnet include NIs, as well as sillimanite and biotite. Biotite commonly occurs as inclusion minerals in the P-poor cores of garnet and rarely occurs as matrix minerals. This mode of occurrence of biotite can be interpreted as almost complete consumption of pre-existed matrix biotite during the prograde to peak metamorphism [e.g., 8]. The pre-existed granitic melt, which is now preserved as NIs in the P-poor cores of garnet, was probably produced through dehydration melting reaction consuming biotite under the sillimanite stability field. The estimated *P*-*T* condition of the P-poor cores of garnet spans the boundary of granulite/UH*T* metamorphism (~ 850 °C/0.1 kbar to ~ 930 °C/12.5 kbar).

On the other hand, in the case of the UH*T* granulite, no evidence of partial melting (i.e., NI) was found in garnet (5 thin sections from single sample). However, melt was probably present during or after the growth of P-poor rims of garnet, because the margins of garnet is partly replaced by the intergrowth of biotite + plagioclase [e.g., 9]. Extremely high-*T* under high-*P* condition was obtained from rutile inclusion in the P-rich mantles of garnet enclosing kyanite and sillimanite (~ 1026 °C at 14.6 kbar). Taking the occurrence of orthopyroxene + sillimanite in the rock matrix into account, this UH*T* granulite experienced the high-*P* granulite facies metamorphic condition (~ 1026 °C at 14.6 kbar) before the formation of diagnostic mineral assemblage for UH*T* under the sillimanite stability field.

Since partial melting is an endothermic process that absorbs heat energy to proceed [10], it must have buffered the temperature increase of the pelitic gneiss during the prograde to peak metamorphism in this studied case. On the other hand, if partial melting was suppressed in the case of UH*T* granulite until peak metamorphism, extremely high-*T* condition can be attained more readily [10]. The possible differences of timing of partial melting between these two lithologies might cause the thermal gap of ~ 100 °C in this studied case.

[1] Kelsey (2008); [2] Hiroi et al. (2019); [3] Tsunogae et al. (2014); [4] Tomkins et al. (2007); [5] Hart et al. (2018); [6] Kelsey and Hand (2015); [7] Cesare et al. (2009); [8] Kawakami and Hokada (2010); [9] Holness et al. (2011); [10] Clark et al. (2011)

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