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Metamorphic pressure-temperature conditions of the Lützow-Holm Complex of East Antarctica deduced from Zr-in-rutile geothermometer and Al_2SiO_5 minerals enclosed in garnet

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The Zr content of rutile coexisting with zircon and quartz is mainly a function of the temperature condition and is calibrated as Zr-in-rutile geothermometers. Because of their robustness under high-temperature conditions, they have been applied to granulite facies rocks instead of the conventional Fe-Mg exchange type geothermometers to estimate more reliable temperature conditions. However, it is recently pointed out that in order for rutile to retain the primary Zr content, rutile must be chemically isolated from zircon and quartz during cooling. In this context, inclusion rutile separately enclosed in garnet can be considered to retain the primary Zr content at the time of entrapment, only if rutile, zircon, and quartz are all enclosed in a contemporaneous domain of the garnet.

In this study, we re-examined the pressure-temperature (P - T) conditions of high-grade pelitic gneisses from selected regions (Akarui Point, Skarvsnes, Skallen, and Rundvågshetta) of the Lützow-Holm Complex (LHC), East Antarctica. The LHC has been divided into the upper-amphibolite facies zone, the transitional zone, and the granulite facies zone, based on matrix mineral assemblages of mafic- to intermediate gneisses. Akarui Point is located in the transitional zone and others in the granulite facies zone.

While previous studies commonly applied the conventional Fe-Mg exchange type geothermometers, we applied the Zr-in-rutile geothermometer of Tomkins et al. (2007) to rutile grains enclosed in garnet that also encloses zircon, quartz, and Al_2SiO_5 minerals. By utilizing the phosphorus zoning in garnet, we defined contemporaneous domains of the garnet and identified coexisting inclusion minerals in each domain. In this way, coexisting Al_2SiO_5 minerals and rutile grains were utilized to constrain the P - T condition of each domain of the garnet.

As a result, samples from Akarui Point, Skarvsnes, and Skallen were shown to have experienced almost the same P - T conditions around the kyanite/sillimanite transition boundary (~ 830 - 850 °C/ ~ 11 kbar). This is significantly higher than the previously estimated peak condition of 770 - 790 °C/ 7.7 - 9.8 kbar based on the conventional garnet-biotite geothermometer in the case of Akarui Point. From Rundvågshetta, where ultrahigh- T metamorphism is reported by previous studies, higher- T condition (850 ± 15 °C/ 0.1 kbar to 927 ± 16 °C/ 12.5 kbar) than those of other three regions was confirmed from inclusion rutile in garnet enclosing sillimanite. Therefore, the

traditional metamorphic zone mapping, which classified Akarui Point as belonging to the transitional zone, does not reflect the highest metamorphic grade attained. It should be noted that the regional P - T conditions estimated from inclusion minerals in this study is that of earlier higher- P metamorphic stage than the regional P - T conditions determined by the metamorphic zone mapping utilizing matrix mineral assemblages. This result indicates that the Zr-in-rutile geothermometer is a powerful tool to reveal the P - T evolution of high-grade metamorphic terrains, when combined with detailed microstructural observations focusing on the relationship between rutile, zircon, and quartz.