Petrologic evidence for ultrahigh-temperature metamorphism in lower crustal granulite xenoliths from Siberian kimberlite pipes

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Paleoproterozoic high-pressure mafic granulites have been known as lower crustal lithology of the Siberian Craton. Those lower crustal granulites were brought to the surface in some kimberlite pipes, and they have been petrologically studied (e.g., Koreshkova et al., 2011). These xenoliths allow to understand a thermal history of lower continental crust with extremely low heat flow. The investigated lower crustal xenoliths were collected from the Udachnaya kimberlite pipe. The xenoliths are characterized by the granulite-facies mineral assemblage of garnet + clinopyroxene ±F-rich pargasite + plagioclase + K-feldspars ±quartz ±F-rich biotite + ilmenite; they are subdivided into clinopyroxene-rich and pargasite-rich granulites. Although mineral assemblages are similar to some previous studies, the investigated samples contain characteristically various exsolution textures in clinopyroxene, feldspars and ilmenite. All these textures might imply slow cooling of granulites. In particular, orthopyroxene lamellae in clinopyroxene vary in thicknesses, lengths, and directions. It indicates that the granulite cooled in comparatively fast.

Solvus geothermometers to the integrated mode composition of exsolved pyroxenes and feldspars suggest that granulites have experienced a high-temperature metamorphism of at least 900°C, which is higher than previous temperature estimations. Pyroxene geothermometer also suggests that granulites have cooled to 600°C. Garnet contains abundant inclusions of Fe-Ti oxides and/or Ti-rich oxide minerals. It is noteworthy that our study newly discovered the occurrence of Fe-rich armalcolite. In pargasite-rich granulites, F contents of pargasite reach up to 0.8 wt% and ones of biotite reach up to 1.6 wt%, resembling to those minerals in some ultrahigh-temperature (UHT) metamorphic rocks in collisional orogenic belts. Applying *in-situ* petrographic thin-section U-Pb dating technique, we could confirm Paleoproterozoic age (1830 ±18 Ma) for metamorphic zircon, textually in equilibrium with garnet and pargasite. Considering the exsolution features and the occurrence of Fe-rich armalcolite, the lower crust would have undergone a Proterozoic UHT metamorphism. Subsequently, it has cooled relatively fast and had stayed under the condition of amphibolite-facies for a considerable time until the Early Paleozoic kimberlite eruption.

Keywords: Siberian craton, high-pressure granulite, ultrahigh-temperature metamorphism, xenolith, armalcolite

