High-K adakitic intrusion in the Sør Rondane Mountains, East Antarctica

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The Pan-African high-K adakitic granites occupies Lunckeryggen area of 25 km^2 in the Sør Rondane Mountains, and consequently the granites were named as Lunckeryggen granite (e.g., Sakiyama et al. 1988). The granites exhibit Rb-Sr whole rock isochron age of 525±32 Ma (Takahashi et al. 1990). Our U-Pb SHRIMP zircon dating on the granites shows 550±1.7 Ma. The adakitic granites intrude into Neoproterozoic older adakitic meta-tonalite (ca.943 Ma) in the south and partly contact with syenite intrusion in the north. We confirmed excellent evidence of magma mingling and mixing of the adakitic granites with the syenite at the boundary. It implies that both magmatism occurred simultaneously. Furthermore, we subdivide the adakitic granites into three groups by their lithofacies: (1) Gray-colored medium-grained Hbl-Bt granodiorite (Gray Gd), (2) Pink-colored medium-grained Bt granite (Pink Gr), and (3) Pink-colored fine-grained two mica granite (Fine Gr). The Gray Gd intrudes both the Pink Gr and the Fine Gr. On the other hand, the intrusive order between the Pink Gr and the Fine Gr were not confirmed. The Gray Gr and the Pink Gr are sometimes hosting the syenitic magma enclaves, whereas the Fine Gr has not them.

The adakitic granites of the Gray Gd, the Pink Gr, and the Fine Gr are categorized to high-K to shoshonitic series on the K_2O versus SiO_2 plot and have high Sr (≥600 ppm) contents and high Sr/Y ratio (≥60 ppm). On the Harker variation diagrams, these three groups sometimes display different chemical trend each other, which suggests that these adakitic granites were derived from different parental magmas. The samples on the MORB-normalized spider diagrams show geochemical characteristics of arc-rerated igneous rocks, such as the enrichment of Rb, Ba, and Ce with the depletion of Nb and Ti. Rb and Y + Nb of those are showing the volcanic arc and syn-collisional signatures on the granite discrimination by Pearce et al. (1984). The trace element compositions imply that the origins of the adakitic granites were generated at a volcanic arc setting.

The petrological study of the syenite intrusion has not been detailed yet. In general, potassium-rich shoshonites mainly originate from partial melting of an enriched mantle (e.g., Bloomer et al., 1989). However, the syenite intrusion displays negative Nb and Ti anomalies on the MORB-normalized trace element patterns. Owada et al. (2010; 2013) investigated minette dikes in Lunckeryggen, which are geologically coeval magmatic activity with both the syenite intrusion and the adakitic granites. The minette magmas are thought to be formed in a within-plate tectonic setting by partial melting of fossil wedge mantle contaminated with subduction-related materials at mantle depth. Consequently, it is quite likely that the minette dikes are corresponded to volcanic phase of the syenite intrusion.

Because the continental collision and crustal shortening (i.e., Gondwana amalgamation) had already continued in the regions of the Sør Rondane Mountains at the time when the adakitic granites were emplaced (e.g., Osanai et al., 2013), formation of the granites by partial melting of a subducted oceanic slab or fractionation of primitive arc magmas seems unlikely. The adakitic samples have extremely high K_2O (around 6.0 wt.%) and K_2O/Na_2O (1.3–2.1), which does not match the original definition of slab-derived adakite (Defant and Drummond, 1990). This type of adakites can be formed by partial melting of a lower part of thickened crust.

We tested a model of modal batch melting to consider the petrogenesis of the adakitic granites. Trace element concentrations of the source material are estimated from the average composition of the mafic microgranular enclaves (MMEs) hosted in the meta-tonalite of the Sør Rondane Mountains. It is a suitable candidate of source for the adakitic granites because the MMEs and the adakitic granites have closely similar epsilon Nd (550Ma) and ($^{87}Sr/^{86}Sr$)i (550Ma) isotopic compositions each other. Geochemical modeling indicates that the Fine Gr of the adakitic granites can only be explained by partial melting of the mafic source with an amphibole bearing eclogite in the residue. On the other hand, the mixing of the 70% modeled magma with the 30% syenite reproduces the trace element compositions of both the Gray Gd and the Pink Gr very well. These results are not inconsistent with our geological observations for the adakitic granites.

Adakite–shoshonite complex has been occasionally reported by recent workers, and its magmatism was generally pointed out the relation with continent–continent collision (e.g. Yuan et al., 2010; Huang et al 2012). Furthermore, adakitic melts produced by a melting of the basaltic lower crust generally have higher K_2O/Na_2O ratios (about 0.5 or more) (Kamei et al., 2009). This reflects the source composition, that is, the basaltic rock in the continental lower crust generally has higher K_2O/Na_2O ratio than the oceanic basalt (Kamei et al., 2009; 2013). This type is sometimes termed as continental adakites (e.g., Moyen, 2009). Therefore, the high-K adakite–shoshonite complex in the Sør Rondane Mountains indicates that a thickened lower crust already completed in the latest Proterozoic (ca. 550 Ma). Therefore, the high-K adakite–shoshonite complex in the Sør Rondane Mountains indicates that a thickened lower crust already completed in the latest Proterozoic (ca. 550 Ma) by the continental collision and crustal shortening.

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