Multiple fluid infiltration during post-peak metamorphism in southern Perlebandet, Sør Rondane Mountains, East Antarctica

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The Sør Rondane Mountains (SRM), East Antarctica are dominated by high-temperature metamorphic rocks and granitoids (e.g., Shiraishi et al., 1997). There are controversial arguments about the tectonic process around the SRM; Jacobs et al. (2003) considers that the SRM are the part of collision zone between East and West Gondwana during the East African-Antarctic Orogeny, whereas Meert (2003) suggests the crossing points of the East African Orogen and the Kuunga Orogen are located around the Dronning Maud Land. The field distribution of Cl-rich minerals and their formation mechanisms have been studied in the SRM (e.g., Higashino et al., 2019; Kawakami et al., 2017; Uno et al., 2017). The previous studies report Cl-rich biotite and hornblende, which are possibly evidence of saline fluid activity, are observed in felsic and mafic gneisses along large-scale shear zones and major tectonic boundaries over 200 km (Higashino et al., 2013, 2019). The Cl-bearing fluid activity is recognized during prograde to post-peak metamorphisms (Higashino et al., 2013, 2019; Kawakami et al., 2017). The NaCl-CO_2-H_2O system is often assumed as fluid composition in the crust (e.g., Liebscher and Heinrich, 2007). However, CO_2-bearing fluid is not reported in the SRM, whereas Cl-bearing fluid has been examined in detail.

Perlebandet is ~10 km long nunataks located at the westernmost part of the SRM, where granites are exposed in the structurally lower part of the metamorphic rocks. Perlebandet was categorized to the NE-terrane which exhibits a clockwise pressure-temperature (*P-T*) path (Osanai et al., 2013). However, Mieth et al. (2014) proposes that Perlebandet is part of the SW-terrane based on the magnetic survey. The counter-clockwise *P-T* path based on petrochronological constraint from northern Perlebandet by Kawakami et al. (2017) supports this interpretation. Kawakami et al. (2017) also reports Cl-rich fluid infiltration during prograde stage. So far, all previous studies in Perlebandet reporting the *P-T* conditions, zircon U-Pb ages, and CHIME monazite ages dealt with samples collected from northern part of Perlebandet (Asami et. al., 2005; Shiraishi et al., 2008; Kawakami et al., 2017). This study deals with pelitic gneisses collected from southern part of nunataks in Perlebandet in order to reexamine metamorphic fluid composition, considering possibility of coexistence with CO_2-bearing fluid.

The studied sample is a garnet-sillimanite-biotite gneiss whose gneissose structure is cut by ~ 1 mm-thick black selvage. The selvage is mainly composed of Cl-rich biotite (~ 0.7 wt% Cl). Andalusite is exclusively present within the selvage. This suggests that Cl-bearing aqueous fluid infiltrated through a thin crack under andalusite stability field during retrograde metamorphism. In the wall rock, garnet breakdown to biotite + cordierite intergrowth is observed. Within the intergrowth, biotite has ~ 0.2-0.3 wt% Cl. In addition, CO_2 and H_2O peaks were detected in cordierite by Raman spectroscopy. This suggests that the Cl- and CO_2-bearing aqueous fluid triggered the garnet breakdown reaction. The *P-T* conditions of garnet breakdown were estimated to be ~750 ºC and ~ 0.3 GPa (cf. Spear et al., 1999). Since the selvage cuts the garnet breakdown texture, garnet breakdown reaction is followed by the selvage-forming fluid infiltration. Using the equation of Kaindl et al. (2006), CO_2 concentration in cordierite was estimated to be ~1.3-1.7 wt%. Chlorine concentration of fluid coexisting with biotite within the intergrowth texture was calculated to be ~ 30 wt% Cl and ~ 12 wt% Cl respectively in the case of melt-present and melt-absent conditions (Chevychelov et al., 2008; Aranovich, 2017). These values are considered to be upper limits for NaCl concentration in the fluid. The NaCl-CO_2-H_2O diagram indicates that the NaCl- and CO_2-bearing aqueous fluid is present as a single phase at ~ 750 ºC and ~ 0.3 GPa (Shmulovich and Graham, 2004). In addition, the re-integrated composition of the matrix perthite gave the equilibrium temperature of 800-900 ºC, assuming pressure condition to be 0.8-1.0 GPa (cf. Kawakami et al., 2017), using solvus of Fuhrman and Lindsley (1988), Kroll et al. (1993) and Benisek et al. (2004). Garnet-biotite gneiss from the same outcrop has nanogranitoids, which are direct evidence for patrial melting, as inclusions in garnet porphyroblast and monazite.

These observations suggest multiple post-peak fluid infiltration and decompression-cooling path in southern Perlebandet; peak metamorphism with partial melts followed by garnet breakdown reaction triggered by Cl- and CO_2-bearing aqueous fluid infiltration and Cl-bearing aqueous fluid infiltration under andalusite stability field. This study does not show counter-clockwise *P-T* path. This is probably due to the granitic body beneath the metamorphic rocks. Therefore, relationship between the metamorphic history constrained from the northern part of Perlebandet and this study should be further examined.

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