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The chlorine-rich fluid activity during granulite facies metamorphism in the continental collision zone

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Metamorphic fluids play important roles in thermal transport, mass transfer (e.g., Helgeson, 1964), metasomatism (e.g., Meyer & Hemley, 1967) and changing stability field of mineral assemblages (e.g., Powell et al., 1991). In the granulite facies rocks, CO_2-rich fluid has been considered important and studies on Cl-rich fluid are not sufficiently available, because fluid inclusions of the Cl-rich one are less observed than CO_2-rich ones. Some of the reasons Cl-rich fluid inclusion is less found are low viscosity and low wetting angle of brines (Watson & Brenan, 1987). However, Cl-bearing brines are increasingly recognized as playing an important role in high-*T* metamorphic rocks (Newton & Manning, 2010). Using Cl concentration of minerals, it is possible to decipher the Cl-rich fluid activity and its role of them in the lower crust.

We have investigated the field distribution of Cl-rich biotite in the pelitic gneisses of the Sor Rondane Mountains, East Antarctica where Late Proterozoic to Cambrian granulites are widely exposed (Shiraishi et al., 2008). Among more than 20 samples studied, a Grt-Bt-Sil gneiss from Balchenfjella was selected as best suited sample to constrain the *P-T-t* condition of Cl-rich fluid activity. This gneiss contains garnet porphyroblasts (5-10 mm) that have P-rich core with oscillatory zoning in P. The core with oscillatory zoning is discontinuously overgrown by the P-poor rim. The discontinuous zoning in P suggests that garnet porphyroblasts have experienced resorption and overgrowth. The garnet core includes Cl-poor biotite and apatite, and those included at the rim are Cl-rich. Coarse-grained (ca. 100 um), round zircon grains are exclusively included in the rim of the garnet porphyroblast and also present in the matrix. This mode of occurrence suggests that Cl-rich biotite and apatite and round coarse-grained zircon were formed almost simultaneously.

The *P-T* conditions of the Cl-rich biotite entrapment in the garnet rim were estimated to be ca. 800 ^{o}C and 8 kbar, and those of the peak metamorphic condition were ca. 850 ^{o}C and 11 kbar, using Grt-Bt geothermometer and GASP geobarometer (Hodges & Spear, 1982). The f_{HCl}/f_{H2O} ratio of the fluid in equilibrium with Cl-rich biotite (Selby & Nesbitt, 2000) and apatite (Piccoli & Candela, 1994) in the garnet rim are ten times larger than that in equilibrium with Cl-poor biotite and apatite in the matrix and the garnet core. The LA-ICP-MS U-Pb dating of the coarse-grained zircon included in the garnet rim gave a concordia age of 600 +/- 13 Ma. Therefore, the Cl-rich fluid infiltration took place at near the metamorphic peak condition of ca. 800 ^{o}C and 8 kbar at 600 +/- 13 Ma and formed Cl-rich biotite and apatite (e.g., Sisson, 1987).

The field distribution of Cl-rich fluid activity shows somewhat linear distribution. Some of them are located near the ductile shear zones (Ishikawa et al., 2011), and suggesting its relation to high-strain zones (e.g., Kullerud et al., 2001). Regional distribution of near-peak metamorphic Cl-rich fluid activity in the Sor Rondane Mountains implies that it is one of the major phenomena in the continental collision processes.

Keywords: chlorine, fluid, biotite, apatite, Sor Rondane Mountains