東南極セール・ロンダーネ山地ブラットニーパネにおける 複数段階の塩素に富む流体活動の意義

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Significance of multi-stage chlorine-rich fluid activity in Brattnipane, Sør Rondane Mountains, East Antarctica

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Chlorine-rich fluid is a powerful solvent, can coexist with CO_2-rich fluid under the granulite facies condition and has low-H_2O activity (Newton & Manning, 2010; Tropper et al., 2011; Heinrich et al., 2004). Reducing the H_2O activity of aqueous fluid by adding NaCl and KCl changes a *dP/dT* of the NaCl- and KCl-saturated wet solidus to positive one and shifts it to the high-*T* side compared to that of the CO_2-H_2O fluid with the same X_{H2O} (Aranovich et al., 2013). The importance of Cl-rich fluid during metamorphism is gradually recognized. However, the *P-T* condition, timing, and scale of Cl-rich fluid activity in the continental collision setting are still not understood. Higashino et al. (2013) found that the Cl-rich fluid infiltrated into the garnet-biotite-sillimanite gneiss from Balchenfjella at ca. 800℃, 0.8 GPa, and 603 ± 14 Ma, by using the Cl concentration of biotite and apatite. In the same sample, modal amount of REE-bearing minerals significantly changed from monazite-dominant one to zircon- and xenotime-dominant one at the boundary of Cl-rich fluid infiltration.

In a garnet-orthopyroxene-biotite gneiss from Brattnipane (Kusuriyubi-one), the Cl-rich biotite is exclusively included in garnet porphyroblasts. Assuming that later Cl-poor fluid did not change the matrix biotite composition significantly and the effect on the *P-T* estimation is small, the garnet-biotite geothermometer (Holdaway, 2000) and the garnet-biotite-plagioclase-quartz geobarometer (Wu et al., 2004) applied to the assemblage of garnet core, biotite present in the matrix and plagioclase included in the garnet give $T \geqq 795$℃ and $P \geqq 0.96$ GPa. This represents the *P-T* condition of garnet formation either after or simultaneous with the Cl-rich fluid activity. From this *P-T* condition, $\log[f_{HCl}/f_{H2O}]$ of fluid coexisted with Cl-rich biotite included in the garnet can be estimated as $\log[f_{HCl}/f_{H2O}] \geqq -2.77$ (Selby & Nesbitt, 2000), as high as the value obtained from Balchenfjella (Higashino et al., 2013). Because the garnet constitute the penetrative gneissosity of this area, the Cl-rich fluid activity took place before or simultaneous with the penetrative gneissosity formation.

In a garnet-orthopyroxene-hornblende gneiss from Brattnipane (Koyubi-one), ca. 1 cm-thick garnet-amphibole veinlets cut the penetrative gneissosity. Chlorine-content of amphibole and biotite gradually decreases with distance from the vein center. Sodium-content of plagioclase and K-content of amphibole also gradually decrease with distance from the vein center. Therefore, this small vein could be formed by Cl-, Na- and K-bearing fluid infiltration. Using the wall rock mineral assemblage of garnet core, biotite in the matrix and plagioclase included in the garnet that is less affected by the Cl-rich fluid infiltration, the garnet-biotite geothermometer (Holdaway, 2000) and the garnet-biotite-plagioclase-quartz geobarometer (Wu et al., 2004) gave $T \geqq 750$℃ and $P \geqq 0.79$ GPa. This would represent the *P-T* condition of wall rock formation. On the other hand, *P-T* condition for the small vein formation is estimated to be 680-820℃, 0.6-0.7GPa from the mineral assemblage of garnet core, hornblende present in the matrix and plagioclase present in the matrix using the garnet-hornblende geothermometer (Ravna, 2000) and the garnet-hornblende-plagioclase-quartz geobarometer (Kohn & Spear, 1990). Using this *P-T* condition, $\log[f_{HCl}/f_{H2O}]$ of the fluid coexisted with the Cl-rich biotite present in the vein can be estimated to be -2.62 to -2.38 which is almost the same value as that obtained from the garnet-orthopyroxene-hornblende gneiss from Kusuriyubi-one taking the error range of *P-T* estimation into account (Selby & Nesbitt, 2000). This observation is the evidence that the Cl-rich fluid infiltrated after the penetrative gneissosity formation. These pieces of observation show that multi-stage Cl-rich fluid infiltration occurred at Brattnipane, implying that the Cl-rich fluid might be the common phenomena during the peak- to post-peak-metamorphic processes in the Sør Rondane Mountains.

With an introduction of pure H_2O, partial melting is possible under these *P-T* conditions. However, positive slope of wet solidus above 0.2 GPa in a brine system (Aranovich et al., 2013) suggests that partial melting does not occur at $X_{H2O} \geqq 0.5$ under these *P-T* conditions. The Cl-rich fluid has low viscosity and low wetting angle (Watson & Brenan, 1987; Holness, 1997) and has much greater infiltration ability than the CO_2-rich fluid. Therefore, it can potentially play an important role in large-scale mass transfer during the high-grade metamorphism without partial melting.

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