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Behavior of REE-rich minerals during Cl-rich fluid activity under granulite facies metamorphism

Fumiko Higashino[1*], Tetsuo Kawakami[1], Satish-Kumar Madhusoodhan[2], Masahiro Ishikawa[3], Noriyoshi Tsuchiya[4], Geoff Grantham[5]

[1]Kyoto University, [2]Niigata University, [3]Yokohama National University, [4]Tohoku University, [5]Council for Geoscience, South Africa

The importance of understanding the role of Cl-rich fluid in the crust is gradually recognized since metamorphic fluid in the granulite facies rocks has been long considered as CO_2-rich in most cases, and the *P-T-t* condition and the scale of its activity are still not clear. Cl-rich fluid and CO_2-rich fluid are possible candidates of low a_{H2O} fluids. Presence of such fluids shifts the wet solidus to the high-T side, and dehydration reactions to low-T (Newton et al., 1998). Cl-rich fluid can coexist with CO_2-rich fluid under high-T condition and is a powerful solvent (Heinrich et al., 2004; Newton and Manning, 2010). In order to understand the fluid-related geological process in the middle- to lower-crust of the continental collision zone, the *P-T-t* condition of Cl-rich fluid activity and the behaviour of REE-rich minerals during Cl-rich fluid infiltration are studied in detail at the Sor Rondane Mountains, East Antarctica where Late Proterozoic to Cambrian granulites are widely exposed.

Among 33 felsic gneiss samples, a Grt-Bt-Sil gneiss from Balchenfjella was selected, since it was best suited sample to constrain the *P-T-t* conditions of Cl-rich fluid activity. This gneiss contains Grt porphyroblasts that have a P-rich core with oscillatory zoning in P. The Grt core includes Cl-poor Bt and fluorapatite. The core of the Grt has been partially resorbed and discontinuously overgrown by a P-poor rim, in which Cl-rich Bt and chlorapatite are included. Coarse-grained, rounded Zrn grains are exclusively included in the rim of the Grt porphyroblast and are also present in the matrix. This mode of occurrence suggests that the Cl-rich Bt and chlorapatite, together with coarse-grained Zrn were formed almost simultaneously. The *P-T* condition of Cl-rich Bt entrapment in the Grt rim is estimated to be ca. 800 ^{o}C and 0.8 GPa. In comparison, peak metamorphic condition is estimated to be ca. 850 ^{o}C and 1.1 GPa. These pieces of observation suggest that Cl-rich fluid or melt infiltrated at the core-rim boundary of Grt. In the case of fluid infiltration, the f_{HCl}/ f_{H2O} ratio of the fluid in equilibrium with Cl-rich Bt and chlorapatite in the Grt rim are estimated to be ten times larger than that in equilibrium with Cl-poor Bt and fluorapatite in the matrix and the Grt core, because Cl concentration of the melt cannot be high enough to make Bt and apatite as Cl-rich as observed in this study (Higashino et al., 2012).

In this sample, there is a tendency that Mnz is included in the Grt core, and Zrn and Xtm are included in the Grt rim. This implies that Cl-rich fluid carried LREE away and brought HREE and Zr in, and that Zrn included in the Grt rim formed simultaneously with the Cl-rich fluid infiltration. The LA-ICP-MS U-Pb dating of the coarse-grained Zrn included in the Grt rim gave concordia age of 603 +/- 14 Ma. Therefore, Cl-rich fluid infiltrated under the near-metamorphic peak condition of ca. 800 ^{o}C and 0.8 GPa during the continental collision process. On the other hand, the rim of Zrn present in the matrix gave concordia age of 564 +/- 17 Ma. The field distribution of Cl-rich fluid activity is somewhat linear, located near the large scale ductile shear zones in the Sor Rondane Mountains. Regional distribution of high-grade Cl-rich fluid or melt activity in the Sor Rondane Mountains implies that it is one of the major phenomena in the continental collision processes. The *P-T-t* condition of Cl-rich fluid activity could be successfully determined because we successfully distinguished the Zrn grains formed by the Cl-rich fluid activity from the detailed microstructural study. Therefore, in addition to understanding the Cl-rich fluid activity itself, understanding the formation mechanism of datable accessory minerals is also important to correctly interpret the meaning of the age obtained.

Keywords: chlorine, fluid infiltration, granulite facies, Sor Rondane Mountains, REE