

Geochemistry of rare earth element in apatite: Application of micro analysis

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As industrial demand of rare earth element (REE), especially heavy REE (HREE) rises, it become important to secure source of REE. REE are supplied from several types of deposit such as weathered residual of granite, carbonatite, alkaline rock, placer and hydrothermal veins. The major proportion of the REE in both intermediate to felsic igneous and sedimentary rocks is contained in the accessory minerals, among which the phosphates such as apatite, monazite and xenotime often play an important role. Apatite is one of the important sources of REE. Experimental study suggests that REE substitutes for Ca in the apatite structure, with uptake being highest in the range Nd-Gd and being lowest for Lu for natural apatite. There are two important factor of the REE substitution of apatite: (1) crystal structure and (2) melt or fluid condition and secondary migration of REE. REE can substitute for Ca in the two Ca positions of the apatite structure; namely Ca1 and Ca2 which are ninefold and sevenfold coordinated, respectively. LREE and middle REE (MREE) have a marked preference for the Ca2 site over the Ca1 site. Moreover, the volatile anion component (F, OH, Cl) might also be a significant factor in the selectivity of apatite for REE because of its marked influence on the stereochemical environment and effective size of the Ca2 site. On the other hand, previous works reported the presence of typically small grains of monazite and/or xenotime in metamorphic rocks both as inclusions within the apatite as well as along apatite grain margins and REE redistribution in apatite. In this study, REE abundances in several types of apatite such as fluorapatite, hydroxylapatite and chlorapatite were investigated by (LA-)ICP-MS and SIMS to discuss REE distribution between apatite and melt and/or fluid.

REE patterns of Durango (Mexico), Quebec (Canada) and Madagascar fluorapatite are characterized by high contents of REE and large fractionation of LREE relative to HREE. REE content of fluorapatite taken from the Hubasami clay is lower than that of Durango and Quebec, which indicates that REE had not been concentrated in apatite during pyrophyllitization. Igneous chlorapatite of Antarctica shows lower REE content than Durango. Previous reports indicate that the substitution of REE is up to two orders of magnitude lower in chlorapatite than in REE-substituted fluorapatite. On the other hand, chlorapatite taken from Snarum (Norway) is characterized by high contents of MREE and HREE and small fractionation of LREE relative to HREE. The Snarum chlorapatite coexists with hydroxylapatite and contains small monazite inclusions, which suggests that REE redistribution in apatite had occurred. Chlorapatite in Chichibu also contains small monazite inclusions.