

Distribution of rare earth element in apatite ore

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Apatite is a widespread accessory mineral in Earth's crust and enriched in light rare earth elements (LREE). In addition, apatite is one of important carriers of U and Th in geological system. Earlier studies suggest that variation in concentrations and distribution of trace elements including REE, U and Th among phosphate minerals are sensitive indicators of rock system at the time of its crystallization, which provides useful information for formation of deposits. There are analytical difficulties to determine contents of trace elements in apatite because apatite often contains small inclusions of REE minerals such as monazite and xenotime. In this study, REE abundances in apatite and monazite were investigated on 10 μm spatial resolution using secondary ion mass spectrometry (SIMS) to discuss REE distribution between both minerals.

Apatite ore samples were taken from Beldih deposit, India, and Chador Malu deposit, Iran, were analyzed. The Beldih apatite deposit is located along Beldih-Kutni Share Zone in the Early Proterozoic metasedimentary rocks, metabasites and granitic rocks. The apatite ore occurs as lens and vein-shaped bodies hosted by chlorite schists, mica schists, quartzites and amphibolites. The Chador Malu magnetite-apatite deposit is considered to Kiruna-type deposit. The deposit, hosted by Precambrian metamorphic rocks, subvolcanic intrusive syenite and rhyolite, are associated with rhyolite-andesite magmatism. The orebodies are thought to be magnetite-filled pipes and lava flows located in the ring zone of a large caldera.

Chemical observation of major element in the Beldih apatite reveals that core including monazite is surrounded by thin rim (20 μm width) characterized by lower Sr and enriched F. REE patterns of the apatite core are characterized by high contents of REE (average 2520 ppm) compared with those of the rim (15.7 ppm) and are consistent with those of typical igneous apatite. The Chador Malu deposit sample contains monazite and xenotime that are less than 20 μm in size. These minerals exist in grain boundary and within apatite and magnetite. Previous works suggest that apatite is partially dissolved and thereby most apatite grains are heterogeneous. REE patterns of the Chador Malu apatite are characterized by higher REE contents (17018 ppm) than the Beldih apatite and negative Eu anomalies. Th contents of both apatite are higher than U contents. The Chador Malu apatite contains larger amount of Th (76.2 ppm) than the Beldih apatite which shows different Th contents between the core (6.13 ppm) and the rim (1.07 ppm).

Both apatite samples show large and various fractionation of LREE relative to HREE. REE contents of monazite in the Beldih and the Chador Malu samples were normalized by apatite of the highest REE contents in each sample. The REE patterns of the Beldih monazite are enriched in LREE. In addition, LREE/HREE ratios of the Beldih apatite correlate with Th contents, which indicates that monazite have concentrated amounts of LREE and Th from the source melt, thereby leading to the depletion of these elements in the apatite core. On the other hand, the REE patterns of the Chador Malu monazite are characterized by flat pattern in LREE, which suggests that REE in monazite is derived from apatite. Therefore, the Chador Malu monazite was probably formed during apatite dissolution.