A new type of REE-bearing deposit accompanied by Blockspruit fluorite mine, the Republic of South Africa

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Volatile components such as fluorine induce rare earth elements (REE) in melt, so some fluorite deposits contain high REE contents. The fluorite deposits become the targets of REE resource. Many fluorite deposits occur in the Bushveld granitic complex, consisting of the Proterozoic Nebo granite, the Republic South Africa. Our research group has carried out field survey of the fluorite deposits since 2007. The REE-bearing fluorite deposits are classified into two types based on the host of alkaline ultramafic rocks (Vergenoeg, Blockspruit, Ruigterpoort) and granite (Buffalo, Slipfontein). The former is enriched in heavy rare earth elements (HREE), and the latter rich in light rare earth elements (LREE). The Blockspruit fluorite deposit is located in the west of the Bushveld Complex. HREE-rich amphibolites intrude into the Nebo granites in Blockspruit deposit. In this study, the surface survey of the Blockspruit deposit was conducted in order to clarify the wide-area distribution of the HREE-rich amphibolites. Mineralogical and geochemical analyses (potable XRF, ICP-MS, MLA and XRD) were performed for the collected samples.

The results of the surface survey show that the fresh HREE-rich amphibolite intruding into the Nebo granite extends at least 600m$^2$. There are some old trenches for mining of fluorite in Blockspruit deposit. Thick weathered amphibolites also occur in the trench, having high REE contents (3395ppm (REO: 0.40 wt.%)). SEM-EDS analysis reveals that REE minerals in the fresh amphibolites contain a large amount of REE-free apatite ($\text{Ca}_5(\text{PO}_4)_3(\text{OH,F,Cl})$) grains replaced by xenotime (HREEPO$_4$) and monazite (LREEPO$_4$). Generally, monazite-(Ce) commonly occurring in nature has the Ce content which is dominant over all other REEs. However the monazite in Blockspruit amphibolite contains the Nd content which is prominent among all other REEs and is identified as monazite-(Nd). Interestingly enough, the weathered amphibolites contain phosphate minerals such as xenotime-(Y) and monazite-(Nd) and have not an apatite grain. Monazite in weathered amphibolite is also monazite-(Nd). These data suggest that REE-free apatite grains replaced by xenotime-(Y) and monazite-(Nd) in the fresh amphibolites were completely decomposed by F-rich hydrothermal fluid and only the xenotime-(Y) and monazite-(Nd) grains remain in the weathered amphibolites on near surface. In Blockspruit, the residual type deposit formed by the weathering of HREE-rich amphibolite occurring by F-rich hydrothermal fluid is a new type of REE deposits.

HREE ratio to the total REE content of the weathered amphibolite is 41.3% with 4.1% (209ppm) Dy. This ratio is comparable with those of the other HREE exploration projects in the world, although the average grade is lower than those of the projects for alkaline rocks. Most of HREE in the weathered amphibolites are included in phosphate mineral phases such as xenotime and monazite. REE ores in this deposit are HREE-rich amphibolites and their weathered residues. Because the weathered amphibolites contain high xenotime content (3%), these minerals will become the target of ore mineral concentration.