Enrichment of rare earth elements in basalt-derived laterite in southern Laos

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Mobility of rare earth elements (REE) in weathering process of igneous rocks has been reported by many precursors and some of the REE-enriched weathered granites in southern China are popularly known as the ion-adsorption type REE deposits. In contrast, little attention has been paid to enrichment of REE in basalts by weathering. In this study, we discuss geochemical characteristics of basalts and enrichment of REE by weathering in the Bolaven Plateau, southern Laos, in order to evaluate the potential of REE resources.

The Bolaven Plateau, composed of the Cenozoic tholeiitic basalts and alkaline basalts, overlie the Mesozoic sedimentary rocks. The tholeiitic basalts consist mainly of plagioclase basalt and clinopyroxene-olivine basalt. The overlying alkaline basalts are composed of olivine basalt, nepheline-olivine basalt and partly nephelinite. These basalts are weathered regionally and formed laterites which are accompanied with low-grade bauxite. The basalts contain small amounts of smectite and kaolinite as weathering products. The laterites consisting of gibbsite, magnetite, goethite, hematite and anatase are depleted in SiO_2 with enrichment of Fe_2O_3 and Al_2O_3.

Studied basalt samples indicate that basalts depleted in SiO_2 and enriched in alkali elements (Na_2O + K_2O) tends to have higher REE contents. The basalts are generally enriched in LREE (light rare earth elements) and relatively depleted in HREE (heavy rare earth elements). In most of laterite samples, some major elements (e.g., SiO_2, MgO, CaO) are leached by weathering whereas contents of immobile elements (e.g., Al_2O_3, TiO_2, Zr) increase relative to parent rocks. Ratios of REE enrichment (REE content of laterite / REE content of parent basalt) are variable with the range of 0.2 - 3.9, indicating that laterites are enriched or depleted in REE by each weathered profile. This result suggests that the leaching of major elements in laterites does not necessarily lead to an increase of REE contents relative to the parent rocks. The enrichment or depletion of REE is probably attributed to pH of groundwater. The most REE-enriched weathered profile has nephelinite as the parent rock, which shows 367 ppm in the total REE content. The nephelinite-derived laterite shows REE contents ranging from 494 to 1444 ppm, indicating the ratios of REE enrichment range from 1.3 to 3.9. The ratios and REE contents are comparable to those of ion-adsorption type deposits in China. The enrichment of REE in this weathered profile results mainly from the leaching of major elements by intense laterization and partly from deposition of REE removed from surrounding laterites. The REE in the laterites occur as aluminophosphate, which is considered to be florencite-(Ce).

The enrichment of REE in alkaline basalts-derived laterites of the Bolaven Plateau is probably attributed to the leaching of major element by intense weathering and to the formation of aluminophosphate mineral immobilizing REE. Additional studies are expected to understand the mobility of REE and formation of REE minerals in basalt-derived laterite in order to assess a potential of the resources.