High-energy μ-XRF-XAFS analysis of ion-adsorption-type rare earth deposit using the synchrotron radiation X-ray μ-beam

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Ion-adsorption-type deposit of rare earth elements (REE), which is a secondary deposit consisting of weathered granite, is very important in terms of sustainable resource development due to the following characteristics; (i) REE can be easily extracted by adding dilute electrolyte solution, (ii) Rich in heavy rare earth elements (HREE), more valuable than light rare earth elements (LREE). (iii) Radioactive elements such as uranium and thorium are not extracted. However, this type of deposit is currently only developed in south part of China. We discovered ion-adsorption-type REE ore. Its total REE concentration and extraction rate are 3750 ppm and 100% respectively, which is comparable to that of China (total REE average concentration and extraction rate are 800 ppm and 50~100%, respectively).

In this study, We performed μ-XRF-XAFS analysis toward ion-adsorption-type REE ore sample in order to identify the host phase of REE and to clarify the adsorption characteristics using the synchrotron radiation X-ray μ-beam at BL37XU of SPring-8. We realized the high-energy X-ray microbeam (photon energy: 40 keV; beam size: smaller than 0.8 μm (horizontal)×0.4 μm (vertical)) using a newly developed K-B mirror system, and performed XRF mapping and K-edge XAFS (HE-μ-XRF-XAFS). Previous REE-XAFS analysis excited L3-edge of REE, with a problem that L-lines of REE are interfered by K-lines of transition elements, when we analyze natural samples including various metal ions. However, the HE-μ-XRF-XAFS is not subject to the interferences.

In addition, we quantitated REE concentration at local area to obtain REE pattern by the method without strong needs to correct the absorption effect, since absorption of X-ray by the matrix material can be negligible for the thin-section analysis using hard X-ray above 30keV. As a result, two types of REE enrichment were observed. One is the widely-distributed REE enrichment which indicates typical characteristics of ion-adsorption-type ore such as negative cerium anomaly, and the other is REE hot spot which indicates typical characteristics of igneous REE mineral with LREE-rich REE pattern.

This method, HE-μ-XRF-XAFS, is superior to laser-ablation ICP-MS in terms of the spatial resolution and determination of REE speciation using EXAFS, which can be a very powerful method for the REE study for natural samples.

Keywords: Rare earth resource, Hard X-ray μ-beam, X-ray fluorescence mapping, X-ray Absorption Fine Structure (XAFS)