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報告番号	※　　第　　号

主　論　文　の　要　旨

論文題目 Applications of the improved Jørgensen equation for tetrad effect of REE^{3+} to the REE patterns of kimuraite and lanthanite, and to the REE distribution pattern between kimuraite and lanthanite

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論　文　内　容　の　要　旨

The kimuraite [$CaY_2(CO_3)_4 \cdot 6H_2O$] aggregate sample collected from Hizen-cho, Saga Prefecture, Japan was divided into seven subsamples, and the Ca and REE compositions of them were measured with ICP-AES and ICP-MS. In the chondrite-normalized REE patterns, all samples yielded parallel concave tetrad patterns, and the mole ratios of ΣREE to Ca were calculated to be 2.5 to 3.4, all of which were obviously larger than the ideal value of 2.0. In addition, electron probe micro-analyzer (EPMA) was also applied to determine the compositions of our samples. Though only four rare earth elements (Y, La, Pr and Nd) were able to be measured, the mole ratios of ΣREE to Ca determined with EPMA were 2.1 to 3.3. Both analytical results indicated that our kimuraite samples might have excessive amount of REE. In the backscattered electron (BSE) images, besides dark kimuraite grains, the presence of another mineral with brighter BSE intensity in the cleavages of kimuraite grains was confirmed, and almost all analysis spots of EPMA failed to escape from the contamination of this mineral. It appears to us that the most possible candidate for this mineral should be lanthanite [$(La,Nd)_2(CO_3)_3 \cdot 8H_2O$], both for its close relationship with kimuraite and for its characteristic chemical composition. Our study first revealed the possibility for lanthanite of several micrometers to be present in the cleavage of kimuraite.

The chondrite-normalized REE pattern of both kimuraite and lanthanite were suggested to display tetrad effects. The improved Jørgensen equation for lanthanide tetrad effect was employed to examine these REE patterns. The chondrite-normalized REE patterns of two lanthanite samples

reported by Nagashima et al. (1986) and Seredin et al. (2009) were applied to improved Jørgensen equation for the lanthanide tetrad effect. The former was proved to be a tetrad effect as it could be quantitatively described by the equation, except for the negative Ce anomaly. In contrary,the latter was not able to be reproduced by the equation, as this lanthanite sample is described as an ore sample, which raises the possibility that it is probably not a pure lanthanite. When suitable corrections were made, it became compatible with the theoretical equation. At the same time, the chondrite-normalized REE patterns of three kimuraite samples from Japan and six kimuraite samples from Russia were investigated by improved Jørgensen equation. The kimuraite sample of Nagashima et al. (1986) and kimuraite B of Akagi et al. (1993) had their chondrite-normalized REE patterns been regressed by the equation, and both of them display W-type tetrad effects. In comparison, the chondrite-normalized REE patterns of the kimuraite of Jiao et al. (2013), as well as all kimuraite samples from Russia, were not able to be reproduced by the equation immediately, if the excessive amount of LREE possibly caused by the contamination of lanthanite was not corrected. This result means the kimuraite samples reported by Seredin et al. (2009) are not pure kimuraite either. Four other samples, which were described as mixtures of kimuraite and lanthanite by Seredin et al. (2009), were immediately fitted by improved Jørgensen equation, suggesting that these samples might represent the REE compositions of a certain homogeneous phase. In addition, the REE partitioning between kimuraite and lanthanite was also studied with the theoretical equation. As a result, improved Jørgensen equation immediately reproduced the lanthanite-normalized REE patterns of three kimuraite samples, confirming that the fractionation pattern of REE between kimuraite and lanthanite can yield a faint tetrad effect. The convex octad effect for lanthanite-normalized REE pattern is consistent with the larger coordination number of REE^{3+} in lanthanite relative to that in kimuraite, though the intrinsic tetrad effects are concave.