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Independent component analysis to decouple geochemical components of REY-rich mud in the Pacific and Minamitorishima EEZ

YASUKAWA, Kazutaka[1*] ; TAKAYA, Yutaro[2] ; OTA, Junichiro[1] ; FUJINAGA, Koichiro[1] ; NAKAMURA, Kentaro[1] ; KATO, Yasuhiro[2] ; IWAMORI, Hikaru[3]

[1]Sys. Innovation, Univ. of Tokyo, [2]FRCER, Univ. of Tokyo, [3]JAMSTEC

Rare-earth elements and yttrium (REY) are essential for state-of-the-art devices and green technologies including electric vehicles, fiber optics, smart phones, wind power generation etc. Recently, the deep-sea sediments enriched in REY (termed as "REY-rich mud") have been discovered in the Pacific Ocean, which have great potential as a completely new REY resource (Kato et al., 2011). In 2013, the presence of REY-rich mud was also confirmed within the Japanese exclusive economic zone (EEZ) around Minamitorishima (Fujinaga et al., 2013; Suzuki et al., 2013). The maximum total REY content in the REY-rich mud from Minamitorishima EEZ reaches as high as 6,600 ppm, although typical REY-rich mud in other regions of the Pacific Ocean contains less than 2,230 ppm of total REY.

In order to elucidate a component contributing to REY-enrichment in the sediments, Kato et al. (2011) performed independent component analysis (ICA) on the geochemical data set of Pacific deep-sea sediments. ICA is a relatively new multivariate statistical method established in 1980s, which can extract original independent source signals or factors from observed signals based on an assumption that the observed multivariate data are mutually independent but do not form a multivariate normal (Gaussian) distribution (Hyvärinen et al., 2001).

Four independent components (ICs) were found by Kato et al. (2011): two diluting components corresponding to biogenic carbonate and silica, and two components toward high REY contents with Fe and Al values, respectively. Kato et al. (2011) interpreted that the Fe- and Al-rich ICs that are responsible for the REY-enrichment of the mud correspond to end-member minerals of Fe-oxyhydroxide and phillipsite, respectively. Recently, however, X-ray absorption fine structure (XAFS) analysis and μ-XRF elemental mapping using high-energy synchrotron radiation revealed that most of REY are directly bonded to apatite in the REY-rich mud (Toda, 2013; Kashiwabara et al., 2014).

Here, we analyze a new comprehensive geochemical data set of deep-sea sediments from the Pacific Ocean and Minamitorishima EEZ by ICA. In this calculation, we utilize the new chemical composition data of individual crystals of phillipsite and apatite measured by LA-ICP-MS as new end-members for the ICA analysis. We will discuss the results and interpretation of our new analysis.

– References –
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Keywords: deep-sea sediment, REE, independent component analysis