Statistically independent components controlling enrichment of rare-earth elements in deep-sea sediments

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Rare-earth elements and yttrium (REY) are critical materials that are indispensable in high-tech devices and green technology applications including electric vehicles, smart phones, LED bulbs, wind power generation, and so on. Recently, deep-sea sediments highly enriched in REY, known as REY-rich mud, have been discovered in the Pacific and the Indian oceans (Kato et al., 2011; Yasukawa et al., 2014, 2015). Because of their huge potential economic value as a new resource for REY, it is becoming an important issue to understand the origin of REY-rich mud.
Elucidating the controlling factors of REY-enrichment in deep-sea sediments is key in finding areas of high resource potential worthy of detailed exploration and for revealing latent relationships between the Earth's system and marine mineral resources. Here we construct a hemisphere-scale compositional dataset of ~4,000 bulk sediment samples from more than 100 sites in the Pacific and the Indian oceans, and we apply Independent Component Analysis originally established in the fields of neuroscience and information science in 1990s, to the huge, multi-elemental data matrix. As a result, we successfully extract the statistically independent geochemical signatures including components controlling the REY-enrichment in deep-sea sediments. The features of the REY-controlling components, including hydrothermal, hydrogenous, and biogenic calcium phosphate components, indicate that an underlying key factor of significant REY-enrichment is a sufficiently low sedimentation rate that enables the mud to accumulate REY from the overlying seawater.
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Keywords: deep-sea sediment, REY-rich mud, Independent Component Analysis

