Mineral composition and grain size distribution of REY-rich mud in the Minamitorishima EEZ: Implication for formation process of extremely REY-rich mud

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In 2011, it was reported that deep-sea sediments containing high concentrations of rare-earth elements and yttrium (REY) are widely distributed in the Pacific Ocean, and can constitute a new mineral resource for the industrially critical elements [1]. Moreover, the “extremely REY-rich mud” containing more than 5,000 ppm of total REY (ΣREY) was discovered within the Japanese exclusive economic zome (EEZ) around Minamitorishima Island [2], and various researches to reveal a detailed spatial distribution of the extremely REY-rich mud has been carried out [3]. However, the formation mechanism(s) of the extremely REY-rich mud have not been completely elucidated yet.

Recently, based on multi-elemental compositions of 49 piston core samples collected from the Minamitorishima EEZ, it was confirmed that the deep-sea sediments in the area could be classified into nine sedimentary units based on characteristic chemical compositions [4]. This chemostratigraphy indicated that there are at least three “ΣREY peaks” containing 2,000 ppm of ΣREY in the Minamitorishima EEZ [4]. A previous study targeting the extremely REY-rich mud corresponding to the 1st ΣREY peak (i.e, the shallowest ΣREY peak in the chemostratigraphy) demonstrated that grain sizes of biogenic Ca-phosphate (BCP) and authigenic phillipsite were largest in the horizon with the maximum ΣREY concentration, based on analyses of mineral composition and grain size distribution [5]. However, whether this feature is common in all of the ΣREY peak units remains uncertain. In addition, no systematic investigation of relationships between each chemostratigraphic unit and mineral composition and grain size distribution has been carried out.

Here, we aimed to characterize each chemostratigraphic unit from the perspectives of the mineral composition and grain size distribution, and also to provide a constraint on the formation process of the extremely REY-rich mud. We selected 80 sediment samples from the 17 piston cores collected within the Minamitorishima EEZ to cover all units of the chemostratigraphy. The mineral composition was estimated by microscopic observation following the standard protocols of the International Ocean Discovery Program. The grain size distribution was measured by using laser diffraction spectroscopy. As the result, we revealed systematic variations in mineral composition and grain size distribution of each chemostratigraphic unit, and confirmed that grain sizes of BCP and phillipsite in all the ΣREY peak units were coarser (i.e., more enriched in silt- to sand-sized fractions) than other units. The increased sizes of BCP grains as a common feature of the ΣREY peaks imply that a grain-size sorting by enhanced bottom currents concentrated coarse BCP grains on the seafloor and contributed to the formation of extremely REY-rich mud for multiple times throughout the sedimentary history of the area.

Reference

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