Sr isotope ratios identify origins of detrital materials in ferromanganese crusts: implication for tectonic and climatic impacts to submarine environment

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Ferromanganese (Fe-Mn) crusts form by chemical precipitation in submarine environments. The crusts are composed of mainly Fe-Mn oxides with subordinate amount of detrital materials. Because Fe-Mn oxides absorb various elements from the surrounding seawater, Ns ad Os isotope ratios in the Fe-Mn crusts reflect those of seawater at the time of precipitation. Therefore, temporal changes in the marine isotope chemistry are recorded continuously and the marine isotope stratigraphy is applicable for dating of the Fe-Mn crusts. In contrast, Sr isotope ratios given by $^{87}Sr/^{86}Sr$ in the unleached Fe-Mn crusts show a common value of the modern seawater due to low temperature exchange of the loosely absorbed Sr in the Fe-Mn crusts with that in the ambient seawater[1]. Therefore, Sr isotope ratios are not suitable for dating. Alternatively, it is possible to identify the sources of detrital materials in the Fe-Mn crusts by examining Sr isotope ratios owing to the unique Sr isotope ratios of some detrital materials.

In this study, we analyzed Sr isotope ratios of the Fe-Mn crusts recovered from off Minamitorishima (Marcus) Island and off NE-Japan using LA-MC-ICP-MS with spatial resolution at 200-μm in both diameter and depth. This enabled analysis of Sr isotope ratios at a high spatial thus temporal resolution. All the data obtained across the surface to the bottom layers of the sample off Minaitorishima Island showed an uniform value representing the present seawater (0.70906)[2]. In contrast, the sample off NE-Japan showed a higher Sr isotope ratio in its surface layer whereas lower than the present day seawater in its inner layers.

The sample off Minamitorishima Island shows low concentrations of detritus-influenced elements, such as Si and K, along with their Sr isotope ratios same with the present day sweater. This reasonably shows low detritus contents in the Fe-Mn crusts. As for the sample off NE-Japan, the distinct Sr isotope ratios suggest influences of various detrital materials contained in the crusts. Based on the existing isotope database, we found three components for the inventories of the distinct Sr isotope ratios; (1) aeolian dusts from China showing a high Sr isotope ratio, (2) terrigenous detritus from NE-Japan arc showing a low Sr isotope ratio, and (3) Fe-Mn oxides showing intermediate Sr isotope ratio of the present day seawater.

The NE-Japan detrital component increased since 2-3 Ma in response to the rapid uplift of the Ou Backbone Mountain Range in the NE Japan arc[3]. The Chinese aeolian dust component gradually increased with time corresponding to the increase of tropospheric aeolial dust flux enhanced by the global cooling and increased atmospheric pressure gradient in the dust source region through the Quaternary[4]. This study revealed a novel use of Sr isotope ratios of the Fe-Mn crusts which enabled to identify the sources and influences of the detrital materials in the Fe-Mn crusts with a high temporal resolution. This approach becomes a powerful tool for decoding the tectonic and climatic histories recorded in the Fe-Mn crusts when the detailed chronology of the Fe-Mn crusts is simultaneously available by applying the marine isotope stratigraphy using the conservative isotopes.

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