MIS33-P01 Room:Convention Hall Time:May 23 18:15-19:30

Growth Process and Metal Accumulation of Hydrogenetic Ferromanganese Crusts: Joint Study in the NW Pacific Seamounts

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We have been conducting a joint program with geologists, mineralogists, geochemists, physical engineers, and microbiologists in order to characterize geochemical and mineralogical variations in space and time of the crusts which have proved most important for effective mineral exploration, resource evaluation, and paleoceanographic reconstruction studies. Our latest cruises including 16 dives using a Remotely operated vehicle (ROV) Hyper-Dolphin 3K of JAMSTEC included in-situ measurement of physico-chemical parameters and careful sampling of undisturbed and uncontaminated ferromanganese crusts at depths between 800-4500m water depths from three typical model seamounts in the NW Pacific The collected samples were analyzed in two series; for a water-depth dependency taken at 500m depth intervals and a secular variation from the very surface to the substrate.

The geochemical and mineralogical analyses resulted in following conclusions.

1) The growth rates or accumulation rates of major elements are quite constant and growth has been continuous in wide ranges of regional areas and water depths. The growth started middle Miocene or much earlier. The rates are amazingly constant within and outside of the oxygen minimum zone (OMZ).

2) Dissolved oxygen profiles are quite similar to each other along the mapping lines. The chemical variability is quite dependent with water depth, which is probably due to stratified water structures.

3) The secular variations in element concentration are generally similar among three areas, indicating again similar pattern of oceanographic and geological history among those.

4) These well-correlated nature and compatible geochemical and mineralogical description may ascertain reliable evaluation and possible exploration of the crusts over the area and water depths.

Keywords: hydrogenetic, ferromaganese crust, manganese nodule, seamount, NW Pacific, rare metal

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Iron isotopic composition of marine ferromanganese deposits

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Iron isotopic composition of marine ferromanganese deposits could be a useful tool to understand the cycling of iron in the ocean. Beard et al. (2003) proposed that the iron delivered to the ocean is essentially controlled by the atmospheric particulate flux (delta-56Fe = 0 permil) and the mid-ocean ridge hydrothermal flux (delta-56Fe = -0.5 permil). However, the global dataset of iron isotopic composition for hydrogenetic ferromanganese deposits demonstrated large variations on local scale and no systematic difference between ocean basins (Levasseur et al., 2004). Thus, further studies are needed in order to determine source and precipitation process of iron in marine ferromanganese deposits. In this study, we preliminary analyzed the iron isotopic compositions of hydrothermal ferromanganese crusts, hydrogenetic ferromanganese crusts, and hydrogenetic/diagenetic ferromanganese nodules.

Keywords: marine ferromanganese deposit, iron isotope

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Chemical Relationship between spatially coupled suspended particles and the crust surface

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Objective:

It is considered that the formation of ferromanganese crusts is mediated partly by sedimentation of Mn-bearing particles from seawater. However, the extremely slow rate of crust formation (~2 mm/ Ma) remains to be poorly explained mainly due to the lack of characterizations for suspended particles in seawater in contact with the crust surface. Although suspended particles have been conventionally collected by water samplers deployed from the ship, it is difficult to collect seawater closely located to the seafloor. Recently, submersibles, which are capable of collecting water samples by observing the seafloor outcrops, provide us opportunities to collect suspended particles above the ferromanganese crusts. The main purpose of this study is (1) to evaluate suspended particles adjacent to the crust surface collected by a submersible, (2) to correlate chemical compositions of collected particles to those of the corresponding crust surface and (3) to validate the submersible-based sampling method to study the formation process of ferromanganese crusts.

Method and samples:

By using a remotely operated vehicle called Hyper Dolphin, deep seawater and crust samples were collected at water depths of 1460-1838 m from Tobu Seamount on the Daito Ridge, Western Pacific. Immediately after retrieval, suspended particles were collected on a filter with 200 nm pore diameter. Thin sections were prepared for crust samples, which were embedded in LR-White resin. Suspended particles on the filter and thin sections of a crust sample at a depth of 1460 m were observed by backscatter electron imaging (BEI) of scanning electron microscopy (SEM) and analyzed by energy-dispersive spectroscopy (EDS) for chemical composition.

Results and discussion:

Among filter samples at seven depths, 1460-m and 1545-m deep samples were abundantly associated with Fe- and Mn-bearing particles. In contrast to the similar size range (average sizes of 1800 and 1600 nm), the Mn/Fe ratio was heterogeneous for the 1460-m deep (0.6-2.5; n=11) and homogeneous for the 1545-m deep sample (0.6-1.1; n=7). Two filter samples at depths of 1614 m and 1753 m were mainly associated with Fe- and Cr-bearing particles. The remaining three samples at depths of 1480 m, 1586 m and 1838 m were not associated with Fe- or Mn-bearing particles but Ca- and C-bearing particles. As for a crust sample at a depth of 1460 m, the homogeneous range of Mn/Fe ratio of ~0.8 at the crust surface was shifted to 1.4 towards the inside. The discrepancy in Mn/Fe ratio between suspended particles and the crust surface might be resulted from the contamination of previously collected crust samples in the sample basket. On the other hand, a good agreement in Mn/Fe ratio between the 1460-m deep crust surface (~0.8) and the 1545-m deep suspended particles (0.6-11) might suggest the natural occurrence of the suspended particles in the vicinity of the crust surface. The Ca- and C-bearing particles are considered to be originally present, while the Fe- and Cr-bearing particles were probably supplied from the metal alloy material used for Hyper Dolphin. It is also known that the dissolution of CaCO3 particles produced by surface bioproductivity and transported through deep-sea circulation is a major process to provide Fe to the ferromanganese crusts. Hence, the major formation processes are potentially clarified by our sampling method and chemical analysis.

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Dual Structure of Ferromanganese Crusts in the Pacific Seamounts: Significance as Resources and Paleoceanographic Record

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We found a wide-spread frequent distribution of Co-rich ferromanganese crusts with marked dual structure; top earthy brownish crusts and underlain submetallic hard and brittle crusts in the central and northwestern Pacific seamounts. The area icludes the Marshall-Wake-Marcus-Bonin Islands. Our fine-scale Be-isotope dating, chemical analysis, XRD, microscopic structural analysis revealed clear difference in major and minor metallic elements. The younger layer is rich in Fe, Si, Al, Co, but depleted in P, but vice versa in the older layer. The boundary is approximately 12-15Ma base on Be data. Thus this marked change in the microstratigraphic section may related with changes in oceanographic and geological environment in the Neogene time.

Keywords: ferromanganese crust, mineral resource, NW pacific, marine environment, seamount

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Uniqueness and commonality of prokaryotic community structures between ferromanganese crusts and hydrothermal polymetall

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Approximately 70% of the surface of Earth is the seafloor. Metal deposits have been found on the seafloor in various areas. Sulfide deposits containing metals such as Fe, Cu and Zn, like chimneys or mounds, and iron-silica-rich deposits occur in the present and past hydrothermal fields (e.g., Kato et al., 2009; Hannington et al., 2011). Ferromanganese deposits rich in Co, Cu, Ni and Zn, in addition to Fe and Mn, are found on the deep seafloor of both hydrothermal and non-hydrothermal fields (e.g., Usui and Someya, 1997; Hein et al. 2000). Previous studies have revealed that diverse prokaryotes (Bacteria and Archaea) are present on and within the seafloor metal deposits (e.g., Kato et al., 2010; Nitahara et al., 2011). Considering the wide distribution of the metal deposits on the deep seafloor and the amount of metals concentrated in the deposits, the activities of prokaryotes in the metal deposits potentially contribute to elemental cycling and maintenance of ecosystems in the global ocean. However, our knowledge of prokaryotes (abundance, diversity, distribution, activity and productivity) on the seafloor metal deposits is still poor. Here, we summarize the recent data of diversity and composition of prokaryotic communities in a variety of metal deposits on the deep seafloor using the latest bioinformatics tools. This provides novel insights into the characteristics of prokaryotic communities on the deep seafloor metal deposits. In particular, we discuss the commonality and difference between ferromanganese crusts and other metal deposits on the deep-seafloor.

Keywords: ferromanganese crust, hydrothermal polymetallic ores, microbial community