

Dense microbial community at the surface of manganese nodule formed in ultra-oligotrophic seafloor

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During IODP Exp. 329, manganese nodule was collected from the seafloor of ultra-oligotrophic South Pacific Gyre, and its microbial and chemical characteristics were investigated. This nodule was formed on red pelagic clay, and its chemical composition and depositional fabrics indicated that this nodule was formed by hydrogenesis. Synchrotron analysis (μ -XAFS) showed that this nodule was mainly composed of δ -MnO₂ and goethite. Microbotryoidal small protrusions at the nodule surface contained relatively high Fe, although there were some high Mn thin layers. Cu content of manganese nodule was about 0.3%, although it was about 10 times higher than that of surrounding sediment.

SYBR Green I staining was applied for cryo-sections prepared from this nodule sample, and revealed that the microbial cell density at the surface part (about 0.5 mm) was almost three orders of magnitude higher than that of surrounding sediment. Sequencing of 16S rDNA (~1400 bp) indicated that the composition of microbial community (both bacteria and archaea) inhabiting in this nodule was different from that of surrounding sediment, showing that manganese nodule provided specific habitat for these microorganisms. Most of recognized bacteria were heterotrophs, and known manganese-oxidizing bacteria were not detected. On the other hand, most of archaea were the member of Marine Group I, and the percentage of *Nitrosopumilus* sp. was especially high at the nodule surface. This organism is ammonia-oxidizing autotrophic archaea, and its metabolism requires multicopper oxidase that utilizes Cu as a cofactor.

Although the availability of electron donor is very limited in the seafloor of ultra-oligotrophic South Pacific Gyre, *Nitrosopumilus* sp. can grow autotrophically even under very low ammonia concentration, and its growth is considered to be stimulated on the Cu-accumulated substances such as manganese nodule. Known manganese-oxidizing microorganisms all possess multicopper oxidase and it has critical roles in manganese oxidation. This fact implies the possibility that *Nitrosopumilus* sp. may contribute to the formation of manganese nodule.