海底堆積物中の生物源マグネタイトの分布と化学的環境による結晶形態の違い

Distribution of bacterial magnetites in deep-sea surface sediments and variations of magnetosome morphology with chemical conditions

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Magnetotactic bacteria (MTB) have attracted interest of paleo- and rock magnetists as a source of magnetic minerals in sediments and from a viewpoint of remanent magnetization acquisition processes. Furthermore, MTB should also play an important role for biogeochemical cycles of iron. MTB are considered to be microaerophilic and most commonly live near or below the Fe-redox boundary. However, their actual distribution within natural deep-sea sediments was little studied. Recent progress in rock magnetic techniques has enabled semi-quantitative detection of fossil biogenic magnetites (magnetofossils) in sediments. Common occurrence of magnetofossils in Pacific red clay (Yamazaki and Shimono, 2013), which contains abundant dissolved oxygen and does not have a Fe-redox boundary, may conflict with the widespread interpretations of MTB ecology mentioned above. For better understanding of the ecology of MTB in deep-sea sediments, we have conducted rock-magnetic, biogeochemical, and microbiological analyses of surface sediments taken from the Japan Sea with a multiple corer. From dissolved oxygen and Fe (II) contents of interstitial water and color reflectance of the sediments, the Fe-redox boundary was clearly detected at 7 to 25 cm below the seafloor at three sites (1770 to 2710m in water depth). Rock magnetic proxies and TEM observations indicate that magnetofossils occur throughout the sediment columns regardless of the distance from the Fe-redox boundary, even at the sediment-water interface. We found that the proportion of magnetofossils with tear-drop morphology increases near the Fe-redox boundary. On the other hand, the morphology of magnetofossils in oxic red clay is dominantly (>90%) octahedral. These results suggest that some species of MTB that produce magnetosomes of tear-drop morphology prefer a chemical condition near the Fe-redox boundary, whereas other species may live in microaerophilic microenvironments around organic particles near the water-sediment interface. Even some species of MTB that yield octahedral magnetosomes might be aerotolerant and prefer oxic environments. To strengthen the notion above, pyrosequencing of 16S rRNA gene sequences was conducted for the corresponding sediments. Among diverse bacterial lineages known to produce magnetosomes, 16S rRNA gene sequences phylogenetically affiliated within the lineages of Nitrospirae known to produce magnetosomes with tear-drop morphology were distributed only around the Fe-redox boundary, whereas those affiliated within the family Rhodospirillaceae (Alphaproteobacteria) and known to produce octahedral magnetosomes were distributed in all investigated sediments regardless of the Fe-redox boundary. Taken together, it is strongly suggested that the dependency on the Fe-redox boundary is different among phylogenetically and morphologically diverse magnetotactic bacteria.

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