Abundant ferromanganese microparticles in oxic pelagic sediments (IODP Exp. 329)

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Manganese is the third most abundant metallic element, after iron and titanium, in the Earth’ s crust, and ferromanganese minerals are sensitive to changes in redox condition. Assessing the formation and preservation of ferromanganese minerals is important for understanding the global marine cycles of manganese and numerous associated trace elements. The most extensive manganese mineral deposits occur on abyssal plains, including those below open-ocean gyres. However, the extent of ferromanganese minerals buried in subseafloor sediments remains unclear. During the Integrated Ocean Drilling Program (IODP) Expedition 329, we drilled the entire sedimentary sequence at 6 sites in the ultra-oligotrophic region of the South Pacific Gyre (SPG), where dissolved O_2 and aerobic microbial communities are present from the seafloor to the sediment-basement interface [1]. By using high-resolution imaging techniques, we found abundant (10^8-10^9 particles cm^{-3}) micrometer-scale ferromanganese mineral particles (Mn-microparticles) in the oxic pelagic clays of the South Pacific Gyre [2]. Furthermore, we established microparticle separation technique by the combined use of density concentration and flowcytometer/particles sorting techniques. Major and trace element compositional analyses revealed that iron and manganese were the major components of Mn-microparticles, while they also contained rare-earth elements. From the number of Mn-microparticles per unit volume of sediment and the global distribution of oxic pelagic clays, we estimated the number of Mn-microparticles to be 1.5-8.8 $\times 10^{28}$ particles, which accounted for 1.28-7.62 Tt of manganese. This estimate is at least 2 orders of magnitude larger than the manganese budget for manganese nodules and manganese crusts on the seafloor. Along with the examination of manganese input, formation, and preservation, this study provides new insights into the global budget of metallic elements in the abundant Mn-microparticles present in deep subseafloor environments.

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