Geology and geochemistry of Fe-Mn nodules in the Japanese Exclusive Economic Zone around Minamitorishima island, W Pacific

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Ferromanganese (Fe-Mn) nodules have long been considered a potential resource for metals, such as Ni, Cu, and Li, that are important in contemporary technology. Extensive areas of densely distributed high-grade nodules have been recognized in the region between the Clarion and Clipperton Fracture Zones (CCZ) in the central Pacific Ocean (e.g., Hein *et al*., 2013, OGR). Japan has approved exploration licenses for future mining in CCZ, although the location's remoteness is an obstacle to mining operations. We discovered a dense field of Fe-Mn nodules on a seamount approximately 300 km east of Minamitorishima Island, in the Japanese Exclusive Economic Zone. Then, it can be expected that the further exploration in EEZ and the future development followed by the self-sufficiency and the stabilization of the market for the rare metal.

To evaluate potential Fe-Mn nodule field esast of Minamitorishima Island as a rare metal resource, we describe results of a geological survey using the *SHINKAI 6500* submersible (dive No. 6K 1207) during cruise YK10-05 of *R/V Yokosuka* in 2010, and geochemical analyses of collected samples. Submersible observations showed that spherical nodules 5-10 cm in diameter almost fully cover the region of high acoustic reflectivity. The large nodules generally consist of three concentric layers: the outermost mottled (sediment-filled) layer L0; the massive black layer L1; and the innermost porous (sediment-filled) layer L2. Geochemical and structural features indicate that the nodules are compositionally and morphologically similar to Fe-Mn crusts, suggesting that they owe their origin solely to prolonged hydrogenetic precipitation of Fe-Mn-(oxyhydr)oxides. As nodules include metals of economic interest, especially Co, Ni, Mo, and W, this deposit should have a high potential for future mining. The changes in nodule composition from the center to the rim may yield information on paleoceanographic events since early Oligocene time.