Rock-magnetic studies on seafloor hydrothermal deposits in the Okinawa Trough

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Investigation of the mineral assemblage of seafloor hydrothermal deposits are crucial for understanding its formation environment and process. Rock-magnetic measurements of the deposits are quick and effective to detect magnetic metal sulfides which are sensitive to the environment. We report our results of rock-magnetic measurements conducted on sulfide ores from seafloor hydrothermal deposits in the Okinawa Trough. One sample is a sulfide ore of chimney structure collected from hydrothermal mound in the Noho Site and others are sediment core samples drilled at the Izena Hole.
X-ray diffraction (XRD) measurements and chemical analyses indicate that the chimney structured ore mainly consist of pyrrhotite and a Cu-Fe-S sulfide. Crystal structure of the Cu-Fe-S sulfide is similar to that of sphalerite and its chemical composition is close to $CuFe_2S_3$. From these characters, $CuFe_2S_3$ isocubanite is the candidate for the Cu-Fe-S sulfide.
Since the magnetic properties of $CuFe_2S_3$ isocubanite were rarely found in the literature, we first conducted low-temperature magnetometry measurements and magnetic hysteresis measurements of isocubanite. Isocubanite was synthesized by heating a cubanite sample (from Henderson No.2 mine, Chibougaman, Qubec, Canada) at 300 ℃ in vacuum (e.g. Sawada et al., 1962; Nenasheva and Kravchenko, 2015). Results of the magnetic measurements showed that isocubanite is weakly ferromagnetic at room temperature, and undergo a magnetic transition to relatively strong ferromagnetic at ~100 K. Saturation magnetization was 0.09 Am^2/kg at room temperature and 0.4 Am^2/kg at 50 K. Similar magnetic measurements were performed on the Cu-Fe-S sulfide in the chimney ore which was magnetically separated from pyrrhotite. The Cu-Fe-S sulfide was paramagnetic at room temperature and became ferromagnetic at below ~100 K. Saturation magnetization at 50 K was ~20 Am^2/kg. Such strong magnetization and sharp magnetic transition at low temperature is inconsistent with the behavior of isocubanite, but rather comparable to that of $Cu_{1-\varepsilon}Fe_{3+\varepsilon}S_4$ 'new phase' reported by Wintenberger et al. (1994) as an ageing product of isocubanite. Results of our magnetic measurements indicate that 'new phase' is a solid solution which includes $CuFe_2S_3$ composition.
Some of the sediment core samples contain a Cu-Fe-S sulfide with similar XRD pattern and chemical composition to that found in the chimney ore. Those sediment core samples also show a magnetic transition at ~100 K. Intensity of the magnetization at low temperature could be explained by assuming that the Cu-Fe-S sulfide in the sediment core samples is isocubanite, based on rough estimate of mineral proportion from XRD.

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