Electrical features of the submarine hydrothermal system around the Iheya-North Knoll area and the Noho Site, Okinawa, Japan, inferred from resistivity and IP properties of drilling samples from the Chikyu CK16-01 cruise

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The exploration and exploitation of submarine hydrothermal deposits are becoming increasingly important for the steady supply of metal resources to Japanese industry. Valuable metal elements are commonly included as sulfide minerals in these deposits. Most of the sulfide minerals generally exhibit a high electrical conductivity, and an anomalous signature of the Induced Polarization (IP) effect. Therefore, electromagnetic investigations have been considered to be effective in finding unidentified sub-seafloor deposits. Understanding the resistivity and IP properties of rock samples taken from the deposits is important for the improvement of exploration techniques and the reduction of risks during exploitation. The present study involved measurements of resistivity and IP properties of drilling samples from the research program entitled "the Chikyu CK16-01 cruise" from February to March 2016.

The drilling research was conducted in the Iheya-North Knoll and the Noho Site adjacent to the Iheya-Minor Ridge (Kumagai et al., in prep.), where an extensive high-temperature hydrothermal system was expected based on previous surveys (e.g., Takai et al., 2015). The present study included complex resistivity measurements with a wide frequency range between 0.01 Hz and 100 kHz, using non-polarizable electrodes in a four-electrode configuration. Most of the measured sulfide samples are of hydrothermal origin, including fine-grained pyrite. Some samples consist of other sulfide minerals such as chalcopyrite, galena, pyrrhotite, and sphalerite. Massive sulfide rocks were rarely sampled, and disseminated sulfide rocks dominated.

The measurements showed the following results. There is a negative correlation between resistivity and porosity. However, no significant correlation was found between resistivity and sulfide mineral fractions, and the measured resistivity values (greater than 1 Ωm) are higher than those of typical massive sulfides (less than 0.1 Ωm), suggesting that the resistivity is controlled by the connectivity of the interstitial sea water filling the pores. Regarding the IP signature, the sulfidic sediments bearing fine-grained pyrite have low phases at low frequencies, and the values increase with frequency. This feature is consistent with experiments by Revil et al (2015), which demonstrated that fine-grained sulfide causes anomalous high phases at high frequencies. According to further data analyses based on the Cole-Cole model, the estimated chargeability exhibits a positive correlation with the sulfide content.

In this study area, it was shown that the presence or absence of sulfide minerals is reflected in the IP properties, rather than in the resistivity values. In general, pore water resistivity decreases with an increase of temperature, resulting in a reduction of bulk resistivity. Therefore, not only massive sulfides but also high-temperature hydrothermal fluids maintained in porous sediments could be identified as a low-resistivity body by seafloor electromagnetic surveys, meaning that more care should be taken in the

interpretation of the resistivity structure.

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