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Electrical and magnetical properties of the sea-floor hydrothermal deposits

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The newly discovered sea-floor hydrothermal deposits in the Japanese EEZ are growing concern as the crucial future mineral resources and to comprehend the reserved amount of the mineral ores are among the key issues for the developments. Electrical and Electromagnetic exploration technologies are prevailing for the onshore mineral deposits due to the significant differences of the electrical properties between the ores and host rocks, but newly improved technologies are demanded for the ocean bottom applications. The electrical and magnetic properties such as resistivities, chargeabilities and magnetic susceptibilities of the ocean bottom samples from Bayonnaise Knoll and Izena Cauldron are measured and combined with the analysis with X-ray Diffractometry(XRD), X-ray Fluorescence Analysis(XRF) and inductively-coupled plasma mass analysis(ICP-MS). Mineral compositions are determined also with visual and reflecting microscope observations. As comparison samples, the KUROKO black ores which are thought to be the same origin as the ocean bottom hydrothermal deposits are obtained from Koshiji and Kosaka mineral deposits and analyzed in the same way.

The resistivities and chargeabilities are measured with the samples saturated with 0.3 ohm-m water to get the ocean bottom properties. The resistivity values from the Izena samples range from 0.1 to several ohm-m, while those from Bayonnaise and Kuroko range from 1 to several 10s of ohm-m, while chargeability values are found to be high for those two areas. Also no practical differences are found for the IP-values between the above two areas. As the results of the XRF analysis, the average iron content of Izena samples is found to be about 28.8%, which is 6 time higher than that of Bayonnaise and KUROKO (average 4.7%). Bayonnaise samples also contain 35.6% of zinc. Crystalline minerals of Bayonnaise analyzed using XRD showed the same tendency as KUROKO, containing more sphaleraite(ZnS) than Izena samples. The mineral contents of Izena samples are distinct from Bayonnaise samples for containing much more pyrite and also containing marcasite and sphaleraite, the resistivity of which is usually higher than those of pyrite or other sulfide minerals. The general order of the resistivity values of the ore minerals are from low to high values of pyrite, chalcopyrite $<$ galena $<$ marcasite $<$ sphalerite. The results of our resistivity measurements show good agreements with the mineral composition obtained from the XRD analysis and the differences between those 2 areas can be explained. From the results of ICP-MS analysis, Au and Ag contents are practically no differences between Bayonnaise Knoll and Izena Cauldron, but associate with the contents proportional to Zn and Pb. The magnetic susceptibilities of the ore samples from Izena Cauldron are higher and proportional relation to the Fe contents. The hexagonal pyrrhotite crystals are observed in the samples which show high permanent magnetism.

From the inspection of the core samples, the width of the mineralization and altered zones is minimum of several cm, and the massive or conglomerate minerals ware obtained. From the observation under a reflective polarization microscope , the ores with the various crystal-grain sizes ware confirmed, it seem to be due to the difference process of the crystallization condition under the ocean bottom such as the concentration of elements, temperature, pressure and redox status. The depth of all the samples used are from shallower than 10m from the ocean bottom, and more samples from deeper layers are needed for the total understanding of the sea-floor hydrothermal deposits.

Keywords: sea-floor hydrothermal deposit, resistivity, chargeability, magnetic susceptibility, chemical composition, mineral composition