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Sensor configuration of a marine small-loop EM survey on hydrothermal mineral deposits

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We propose a marine small-loop EM survey to detect conductive hydrothermal mineral deposits under the deep sea and estimate their parameters for the economic analysis. Since the marine hydrothermal deposits are usually distributed in a wide tabular form on the sea-bottom sediment. Our main concern is sufficient to define the boundaries and the depth extent of conductive hydrothermal deposits. We also keep an extraordinary condition in mind that transmitter and receiver sensors are located in a very conductive marine environment.

Recently, several surveys using bi-static EM sensors mounted on a remotely operated vehicle (ROV) has been tried for exploring marine hydrothermal deposits. Those are qualitative approaches that show the applicability of EM survey in marine environments and a quantitative analysis is required for economic feasibility study and successive planning for development of marine hydrothermal mineral deposits.

In this study, we calculated one-dimensional responses for a four-layer earth model including air, deep sea, conductive hydrothermal deposit layer and the basement. Two types of sensor configuration are tested and compared: bi-static and mono-static antennas.

Both configurations showed sensitive characteristics to the conductivity of the hydrothermal deposits, but it appeared not to be easy to detect the depth extent of the hydrothermal deposits.

In bi-static configuration, for example, the depth of investigation is a function of the antenna separations; thickness larger than 10 m of the hydrothermal layer whose conductivity is 10 S/m was hard to resolve when the distance between sensors was 10 m. Considering the fact that small loop EM system should not be too big for practical applications, the source-receiver separation cannot be long enough. In those practical aspects a mono-static configuration is more practical than bi-static system in resolving the depth extent of the mineral deposits. Mono-static system, however, still have a limitation on bucking-out the primary fields in a conductive marine environment. We affirmatively expect a possibility of the marine small-loop EM survey for detecting hydrothermal mineral deposits, although actual application to an investigation still needs more studies and considerations.