Full waveform inversion of controlled-source electromagnetic exploration of submarine massive sulphdies

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Controlled source electromagnetic (CSEM) method is widely used for shallow subsurface exploration to estimate detailed resistivity structure. Recently, theoretical and experimental attempts have been initiated to survey submarine massive sulphides (SMS) using electromagnetic method. There are two major issues to address to develop in the exploration of SMS. One is inversion methods that have been developed in the frequency domain, although these methods require solutions for each frequency in the source spectrum. In time-domain electromagnetic method, finite-different time-domain (FDTD) method is often used for forward calculation. However, many previous researches showed that FDTD method with low frequency transmitter requires huge number of time steps. We solve this problem employing fictitious wave domain method (Mittet, 2010). The other is the ambiguity in the orientation of source and receiver transmitters From previous researches, observed electromagnetic fields highly depend on the orientation of transmitter. Weiss and Constable (2006) discussed the influence of the orientation of transmitter/receiver to Fréchet sensitivity kernels.

In this study, a full waveform CSEM inversion with the fictitious wave domain method was developed and implemented for a synthetic model (Fig. 1). We discussed our results in terms of resolution of inversion results, considering distribution and orientations of transmitter/receiver. From the results (Fig. 2), we found that the resolution highly depends on the orientation of dipoles. We integrated results of different oriented dipoles. As a result, the resolution of deeper area is improved with 3-components transmitter. Through all numerical results, we conclude that it is important to consider optimum orientation of dipoles for effective inversion.

References

Mittet, R. (2010). High-order finite-difference simulations of marine CSEM surveys using a correspondence principle for wave and diffusion fields. *Geophysics*, *75*(1), F33.

Weiss, C. J., & Constable, S. (2006). Mapping thin resistors and hydrocarbons with marine EM methods, Part II — Modeling and analysis in 3D. *Geophysics*, *71*(6), G321.

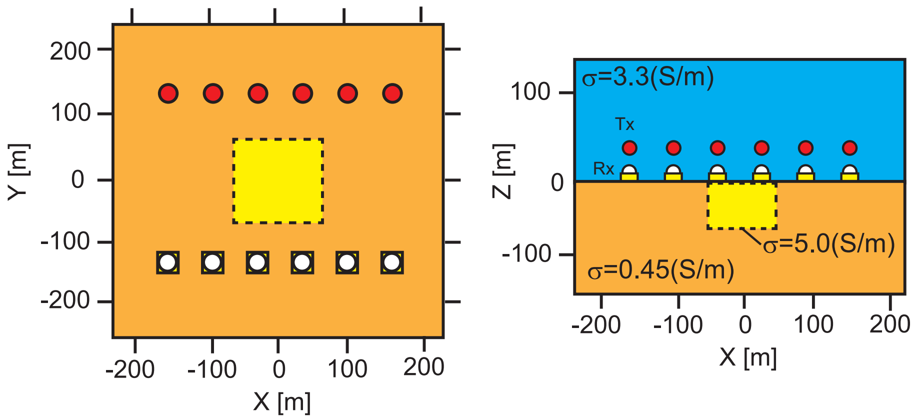

Figure 1: The synthetic model with a 3D alignment of transmitter and receivers consisting of conductive anomaly, seawater and resistive basement.

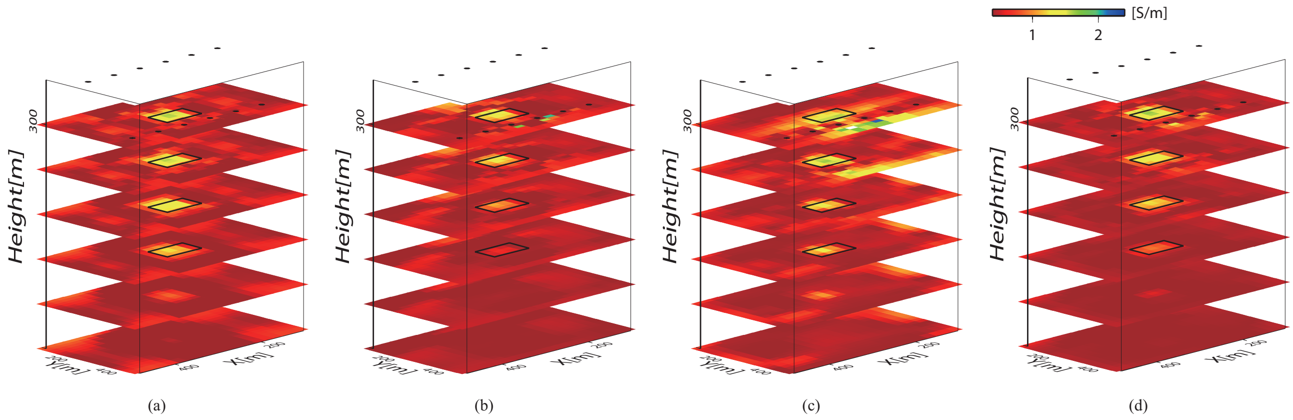

Figure 2: Comparison of inversion results changing the orientation of transmitter. (a) Inversion results with x-oriented transmitter. (b) Inversion results with y-oriented transmitter. (c) Inversion results with z-oriented transmitter. (d) Inversion results with 3-components of transmitters.