

Inversion of marine magnetotelluric and controlled source electromagnetic data with site gap and low signal-to-noise ratio

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SUMMARY

A marine survey using MT and CSEM methods can obtain a high-resolution crustal and upper mantle model. Unfortunately, in the practice of the marine survey, it is not uncommon to see problems of site gaps and noisy data in the collected data set (Corseri et al., 2021; Imamura et al., 2018; Tada et al., 2014). The site gap problem may arise from unrecoverable OBEMs, inaccessible water depth, or uninterpretable data due to excessive noisy data. These could cause a site gap dozens of kilometers long. In such a scenario, the site gap generates additional uncertainties in the inversion models and significantly lowers the model's credibility and resolution.

Marine MT and CSEM methods have recently been widely applied to image the resistivity structures of the subduction zones and based on which to estimate the water contents and their release paths. However, site gap problems could usually occur in a subduction zone profile that often crosses the deep trenches on the seafloor (Naif et al., 2013). In order to better image the submarine structures in these areas, it is necessary at present to understand the negative influence of the data gap and to find approaches to minimize it for improved reliability of our geological interpretation. A few researchers have realized that the site gap may reduce the constraint on the models (Corseri et al., 2021). However, the specific consequences produced by the site gap have not yet been studied or reported. It is also unclear what the combined effects of the site gap and the low signal-to-noise ratio are on the locations, ranges, and resistivities of the anomalous bodies in the inversion model.

In this paper, we investigate the individual and combined effects of site gaps and data noises on the inversion models through synthetic analyses based on a simple block resistivity model and a realistic resistivity structure derived from the Mariana Trench. The results suggest that data with a sufficiently high signal-to-noise ratio can reasonably recover the sub-seafloor structures in the area of data gap. The transverse electric (TE) mode and tipper data from the MT method are much more sensitive to the structure near the site gap. The joint inversion of MT and CSEM data would improve the model's resolution at the site gap area. The inversion of data with a relatively low signal-to-noise ratio, for example, 10 %, can recover the structures with few artifacts if there is no site gap. But if the site gap and noisy data are combined, even a joint inversion cannot correctly recover the burial depths and geometries of the anomalous bodies beneath the site gap where vertical strips are likely present. To improve the model's resolution and suppress inversion artifacts, we propose constraining part of the model with as much a prior information as possible. Specifically, for a survey in the subduction zone, we could reduce the penalties on the model's smoothness at the upper and low interfaces of the resistive subduction slab, or even fix the resistivity of the resistive slab with the help of other information, if any. The inversion models shown in this paper provide valuable references for the site design before marine MT and CSEM surveys as well as for interpreting real data inversion models that may be subject to the same biases introduced by the site gap and noise.

Keywords: Marine controlled source electromagnetic (CSEM), Marine magnetotellurics (MT)

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