

Applicability of fictitious domain method in data processing of marine CSEM exploration

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Marine controlled-source electromagnetic (CSEM) survey, one of the electro-magnetic (EM) sounding methods, is considered as a technique in practice for the exploration of hydrocarbon resources including methane hydrate (MH). In the analysis of EM field acquired in CSEM survey, forward modeling is used to model sub-seafloor structure. In the forward modeling, transforming the diffusive Maxwell equation to a fictitious wave domain reduces CPU time (Mittet, 2010). Phase velocities of electromagnetic waves are a function of material properties, i.e., electric conductivity and magnetic permeability. In the fictitious domain, the difference in the phase velocity as a function of materials is exaggerated so that EM field could propagate in the earth with much slower apparent phase velocity compared to the other field propagating through materials above seafloor. However, such character of the fictitious wave domain has not been well exploited for the estimation of subsurface resistivity structure. In the present study, we examine whether the received waveforms in the fictitious wave domain could highlight MH responses better than in the diffusive domain. We conduct numerical simulations using a three-dimensional resistivity model composed of seawater and earth layers, and a thin MH zone of a rectangular shape. Our results show that the sensitivity to the MH response in the received waveform is improved in the fictitious domain. It is mainly due to the separation of EM waves travelling with different phase velocities through the sub-seafloor layers and seawater in the fictitious domain. We then tested to see if the transform from the diffusive domain (e.g., observed EM field) to the fictitious wave domain is possible or not for further utilization of the transform. As a result of the singular value decomposition method to achieve the transform, the transforming EM waves in the fictitious domain indicated that the sensitivity to MH becomes about twice as much than the original EM field in the diffusive domain.

Keywords: CSEM, Fictitious wave domain, methane hydrate