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Improvement of gas hydrate response in marine controlled-source electromagnetic exploration using fictitious wave domain

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While most of gas hydrate deposits is found clearly on seismic sections as cross-bedding events of the Bottom Simulating Reflector (BSR), the detailed structure of gas hydrate concentrated zones is not well estimated. We focus on marine controlled-source electromagnetic (CSEM) exploration considered as a technique in practice for the exploration of hydrocarbon reservoirs including resistive gas hydrate.

Recently, transforming the Maxwell equation from the diffusive domain to the fictitious wave domain has been developed to reduce computational time (Mittet, 2010). Although the diffusive Maxwell equations require a large number of time steps in finite-difference time-domain (FDTD) method to satisfy the stability condition, the number of iterations could be greatly reduced in the fictitious wave domain. However, the characteristic of the propagation in the fictitious wave domain has not been well exploited, and has potential for a new imaging technology of subsurface structures. In this study, we suggest a new data analysis approach to transform the data from the diffusive domain to the fictitious wave domain. Since the application of the transformation has a potential for improving the response of gas hydrate in the subsurface, we conduct some numerical experiments and discuss the applicability of our approach to the gas hydrate detection and evaluation.

We assumed a 3D resistivity model as a sub-seafloor structure including anisotropic resistive gas hydrate for simulating the inline CSEM exploration. By employing the singular value decomposition (SVD) method, we transformed the received data from the diffusive domain to the fictitious wave domain. Since the stability and accuracy of the transformation depend on the threshold of singular value, we adopt the appropriate value with considering the noise floor. Finally, our results indicate that the separated gas hydrate response becomes about twice as much than the case in diffusive domain.

Keywords: marine CSEM exploration, fictitious wave domain, gas hydrate, anisotropy