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Numerical study of deep towed marine direct current resistivity

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Amount of methane hydrate (MH) could be found distributed around the continental margins and permafrost regions formed under high pressure and low temperature conditions. Methane hydrate has been expected to become one of significant resources in the near future. In the past few years most marine geophysicists have investigated methane hydrates using active seismic explorations for bottom simulating reflectors (BSRs). Although BSRs are an indicator of a solid-gas boundary below the seafloor but we may suffer a lack of information on physical properties of sediments above BSRs only using seismic reflection data. Therefore, uncertain physical properties of MH above BSRs need to be estimated for detecting methane hydrate bearing formations. Since MH has high electrical resistivity in contract to general marine sediments, resistivity measurements such as marine direct current resistivity sounding could be one of feasible methods to be applied in MH exploration.
In this study, the authors test the feasibility of sub-seafloor exploration using traditional direct current (DC) resistivity sounding with the Wenner array and the pole electrical dipole (PED), vertical electrical dipole (VED) and horizontal electrical dipole (HED) arrays, respectively. For this objective, we conducted numerical simulations using 3D forward and 2D inversion algorithms for a model with seawater layer with additive receiver noise to data. Our 3D numerical results demonstrate that the marine DC method is a powerful geophysical tool to investigate sub-seafloor electrical structures with a resistive body such as MH. Various dipole offsets of VED source provide more distinct results to investigate the structures with 20 to 35% anomaly in the electric field when receiver electrodes are settled at the zero offset of about 100 to 150 m to the VED source. The simulated electric fields for the PED and HED sources yield similar results to each other with anomalous electric fields with 10-15% at the offset of 150 to 200 m from the zero offsets. The sensitivity gradually decreases as the offset becomes longer for the PED source.
For the 2D inversion results, the Wenner array shows the poorest resolution, while PED and HED better in this order. The sensitivity derived from the above anomalous electric fields seems directly reflects the resolution in imaging for the PED and HED arrays. We confirm that the imaging resolution also relies on the offset for both the PED and HED cases. The results of our study clearly indicate that electrical sounding is one of feasible methods in the exploration of electrically resistive target in marine sediments. The type of sources and the offset distances are also found key parameters to have the best detectability in the exploration.

Keywords: Deep towed, Marine direct current resistivity, Mathane hydrate