

Advancing the Magnetometric Resistivity Method: 3D Forward Modeling with the Relaxation Technique

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SUMMARY

The Magnetometric Resistivity (MMR) method, introduced by Edwards et al. (1978), is a technique utilized in Controlled Source Electromagnetic (CSEM) surveys. The marine MMR setup comprises a bipole source and receivers. The former consists of two electrodes connected by electric wires generating an artificial current between one electrode on the sea surface and the other on the seafloor, and the latter are called Ocean Bottom Magnetometers (OBMs) that are deployed on the seafloor to measure three components of the magnetic field, including that induced by the bipole source. Unlike most CSEM methods that use horizontally aligned sources, the operation of the MMR method simply keeps the height of the lower electrode above the seafloor at a constant level. This simplicity allows surveys in challenging environments such as rugged seafloors and ridges.

We have developed a 3D forward modeling software which treats the bipole source as two point-sources of equal magnitude but opposite electrical polarity connected by a straight wire. The electric potential field in a 3D electrical resistivity structure with designated point-sources is solved using a relaxation method. However, the singularities at the point-source locations make it challenging to compute accurate current densities from the obtained electric potential field. We overcame this problem by calculating the difference between the electric current density fields of a 3D electrical resistivity structure and a simple half-space structure, where the effect of singularity is almost common. We then derived the magnetic field within a 3D electrical resistivity structure by combining this difference with the analytical solution modeled in a half-space, thereby obtaining a refined representation of the magnetic field variations.

The developed software allows us to simulate the magnetic fields induced by electrical resistivity anomalies within the oceanic crust as detected by the MMR method. In this study, we will discuss the relationship between sub-seafloor anomalous bodies and the magnetic fields observed by OBMs and demonstrate an effective approach to explore these anomalies using the MMR method.

Keywords: magnetometric resistivity (MMR) method; relaxation technique; singularity problem
