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Development of three-dimensional magnetotelluric inversion scheme using the unstructured tetrahedral element

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Thesis outline

A three-dimensional magnetotelluric inversion scheme using the tetrahedral element has been developed in order to precisely incorporate topography into computational mesh. Electromagnetic fields and response functions are distorted at the observation sites of magnetotelluric surveys due to undulating surface topography. Without correcting this distortion, the subsurface structure can be misinterpreted. Among the approaches to simulate the electromagnetic field on the survey area with complex topography, the finite element method using the unstructured tetrahedral mesh is considered to be the most effective one because it can represent complicated objects precisely and robustly with relatively small number of elements. Therefore, the author developed an original three-dimensional magnetotelluric inversion scheme using the unstructured tetrahedral mesh.

The forward modelling of the developed scheme uses the edge-based tetrahedral element, and the subsurface resistivity structure is estimated by solving the nonlinear inverse problem with the Gauss-Newton method. The forward modelling of the scheme was verified by comparing the calculated response functions to the reference solutions. The developed inversion scheme was then applied to the

synthetic data of the various models, and it was confirmed that the developed scheme effectively prevents the misinterpretation of subsurface resistivity due to topography.

Subsequently, in order to demonstrate that the developed scheme can also produce sensible results with measured magnetotelluric data, it was applied to two field-observed datasets. The first one is the data of a dense magnetotelluric survey around Asama Volcano. In the estimated resistivity structure under the volcano, there is a widespread conductive layer below the resistive surface layer and resistive bodies located under the old eruption centres. By comparison with the results of the previous hydrological and geochemical studies, the present work was able to infer the relationship between the resistive area formed by magma intrusion and the characteristic distributions of the SO_4^{2-} and Cl^- concentrations of the spring water and diffuse CO_2 flux.

The second data set is a marine magnetotelluric dataset observed around a sea knoll. By the three-dimensional modelling using the mesh with the precise bathymetry, the present study revealed the characteristics of the dataset can

approximately be reproduced by a simple two-layer structure and bathymetry.