

## Three-dimensional anisotropic inversion of ZTEM data using unstructured finite-element method

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### SUMMARY

As an airborne EM method induced by natural sources, Z-Axis Tipper Electromagnetic (ZTEM) technique is an airborne EM method that detects anomalies in the deep earth induced by the natural sources. ZTEM data are tippers that relate the local vertical to the orthogonal horizontal fields measured at a reference station on the ground.

Since the noticeable difference between airborne ZTEM and the ground magnetotelluric (MT) is the sensor location, one can follow a similar 3D inversion procedure for ZTEM data as is conducted for MT data. Traditional 3D ZTEM or MT forward modeling and inversions typically assume an isotropic earth model. However, interpreting data influenced by anisotropy using an isotropic model can yield incorrect results. Moreover, ZTEM data can be significantly impacted by topography. Existing ZTEM forward and inversion methods often rely on structured grids with limited accuracy, unsuitable for inverting complex underground structures and topography. To effectively model and recover earth structures, including anisotropy and topography, we have developed a 3D ZTEM inversion framework for a triaxial anisotropic model with arbitrary topography.

The forward problem is formulated using the unstructured finite-element method under the assumption of anisotropy theory. A minimum-structure inversion procedure which is one of the gradient-based methods is used for the triaxial anisotropic inversion. To solve the inverse problem, we use a limited-memory quasi-Newton algorithm (L-BFGS) with a parallel direct solver for optimization that avoids the explicit calculation of the Hessian matrix and saves the memory and computational time. To validate our forward and inversion algorithm, we run numerical experiments on two synthetic models and invert a survey dataset acquired for a tunnel project in Tibet, China. All experimental results demonstrate the effectiveness of our unstructured finite-element and L-BFGS method for inverting ZTEM data for anisotropic models with topography.

**Keywords:** Anisotropic inversion, ZTEM, Unstructured Grids

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