

### 3D forward modeling and analysis of a long-offset transient electromagnetic method for an arbitrarily anisotropy earth

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Currently, the inversion and interpretation of long-offset transient electromagnetic (LOTEM) data are always based on the isotropic 1D or 2D conductivity models. However, interpretation errors can occur in regions with distinct electrical anisotropy based on such models. To investigate the influence of electrical anisotropy on LOTEM responses, we developed a three dimensional robust finite-volume (FV) forward modeling algorithm for simulating LOTEM responses in an arbitrarily anisotropic Earth through solving the time domain Helmholtz equations. The accuracy and validity of the method is demonstrated using a 1D layered anisotropic conductivity model and a 3D complex isotropic conductivity model.

The algorithm was applied to analyze and interpret the LOTEM field data in this paper. The LOTEM surveys were carried in an old mining area in eastern Thuringia, Germany. The general existence of black shale had been demonstrated in this area, producing the bulk anisotropy. We designed an 1D arbitrarily anisotropic model based on the 1D isotropic time domain LOTEM inversion outcome. The 1D influences on electrical anisotropy are then revealed by a comparison of modeling responses of the isotropic and anisotropic model. Some incorrect model structures are introduced, when we use the isotropic model to fit the anisotropic response by a 1D isotropic inversion.

A 2D model was designed based on the 2D frequency domain LOTEM inversion model. We compared the time domain modeling outcome of this 2D model with the observation data and calculated the data fit  $\chi$  at all observed locations. The data fits are good at most locations where  $\chi$  are around 2, and there are only several locations with large  $\chi$ . According to the 2D model structure and the geological information, a conductivity anomaly in this model is inferred as a black shale body. Assuming that black shale has an anisotropic structure, we designed a series of 2D anisotropic models with different anisotropic parameters including anisotropic ratio and dip angle. Lastly, a 2D anisotropic model was formed to fit the observed data especially at locations with bad fit of the original model.