EGU25-20819, updated on 28 Nov 2025
https://doi.org/10.5194/egusphere-egu25-20819
EGU General Assembly 2025

3D AEM inversion considering IP effect for mineral exploration in Semacret project

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Modelling Induced polarization effects in airborne electromagnetic (AEM) data is becoming a standard tool in mineral exploration, but the industry standard is still based on one-dimensional (1D) forward and Jacobian modelling. We have developed a three-dimensional (3D) vector finite element electromagnetic forward and inversion method considering IP effects within the EEMverter modelling platform. The computations are carried out in frequency domain, and then time- transformed in time domain through a Hankel transform. This allows to model any parameterization of the IP phenomenon, from the simple constant phase angle model to a full debye decomposition. We present AEM survey data from Semacret project, which contain significant IP anomaly responses. Our test results show that the anomaly distribution of the 3D EM-IP inversion agrees well with the known geological drill hole data.

Airborne electromagnetic (AEM) exploration technology, recognized for its efficiency, flexibility, and indifference to complex terrains, has been extensively applied in hydrogeological mapping geothermal exploration, and energy resource surveys. Due to the typically large-scale datasets collected via AEM, employing inversion methods based on one-dimensional (1D) forward operators remains a conventional and mainstream strategy for data interpretation. In geological settings where the terrain is flat and the subsurface media are approximately layered, 1D inversion can provide relatively accurate interpretations. However, in regions where the terrain is rugged and the distribution of subsurface media varies significantly in different directions, such as mineral deposits, 1D forward modeling is no longer applicable and three-dimensional (3D) inversion is required for proper interpretation.

To meet the demand for detailed interpretation of airborne electromagnetic data for mineral resources, this study employs the vector finie element method, which is known for its high flexibility and computational accuracy, to perform 3D EM forward modelling and inversion. The main features include: 1) the use of Octree meshes to accelerate the meshing process and allow further mesh refinement during inversion iterations, 2) calculation of complex resistivity responses in the frequency domain, enabling easy simulation of any parameterized model of IP, and 3) the independence of the forward modeling mesh from the inversion model mesh, requiring the calculation of the Jacobian matrix only in the footprint area of the forward modeling mesh during inversion iterations.