Three-Dimensional Joint Inversion of ZTEM and Magnetotelluric Data from the Morrison Porphyry Copper Deposit, British Columbia

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Abstract

The airborne Z-Axis Tipper Electromagnetic (ZTEM) method uses natural low frequency electromagnetic signals in the range 30-720 Hz to determine electrical conductivity from the surface to a depth of 2 km. ZTEM measures vertical and horizontal magnetic fields and is effective at determining lateral changes in conductivity, but has poorer vertical resolution than the ground-based magnetotelluric (MT) method. Broadband MT surveys have the advantage of collecting both electrical and magnetic field data in the range 0.001-1000 Hz, and can resolve features at greater depth than ZTEM. However, MT requires ground contact to measure electric fields and is slower and more expensive to deploy. Since both methods derive the tipper from measurements of the vertical and horizontal magnetic fields, both datasets can be inverted simultaneously to create electrical conductivity models. We show with a synthetic model that a limited MT survey can be sufficient to improve the inversion of larger-scale ZTEM surveys.
ZTEM is used to resolve metallic sulfide-bearing ore bodies based on the resistivity contrasts that characterize the deposits relative to the host rock. We present a case study from the Morrison copper-gold porphyry system located in the Babine Lake region of British Columbia. The deposit is related to an Eocene biotite feldspar porphyry stock (BFP), which intruded into Middle-Late Jurassic sediments. Alteration and mineralization zoning at Morrison are centered on the BFP stock. Proximal potassic alteration is associated with disseminated chalcopyrite and minor bornite. Outward, distal chlorite-carbonate alteration is mainly accompanied with pyrite. These different alteration and mineralization zones give different electromagnetic responses, and the resolution can be improved by using our MT data to constrain the inversion of the ZTEM data. Our research shows that inverting a combination of MT and ZTEM data brings out the advantages of each technique and creates a more comprehensive three-dimensional conductivity model.