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Investigation of Potential Brine Plumes by Reinterpreting AEM Data using ERT and Borehole Constrained Inversions

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Summary

Canada is the world's largest potash producer. Potash tailings, if not properly managed, can result in high salinity leachate which can potentially impact vulnerable groundwater resources. Airborne electromagnetic (AEM) surveys are an effective tool to map large areas at the watershed scale in order to characterize hydrostratigraphy and map the extent of potential brine plumes. However, apparent electrical conductivity maps from frequency-domain surveys alone may give an incomplete picture, as can unconstrained inversions in the absence of intrusive information. Further uncertainty can arise in the presence of electrically conductive lithologies (e.g., shale) which can exhibit similar geoelectric properties as groundwater impacted by elevated salinity leachate, leading to ambiguous interpretations. A combined approach utilizing AEM, surface and downhole geophysics, borehole lithologies, and groundwater chemistry to ultimately run a constrained AEM inversion is required to overcome these uncertainties.

Methodology

Here we present a case study from the Rocanville Potash Mine near Rocanville, Saskatchewan. Geophysical surveys are conducted regularly in the vicinity of the tailings management area (TMA) in order to monitor ground conductivity. Previous geophysical surveys have involved ground-based EM (e.g., EM34), geophysical borehole logging, and AEM surveys (2009 and 2016). This case study used a 2016 RESOLVE AEM data set, inverted using constraints from electrical resistivity tomography (ERT) and a Pierre Shale bedrock surface extracted from boreholes. Approximately six kilometres (km) of ERT were collected over the site in 2020, in addition to the logging of 18 groundwater monitoring wells with natural gamma and induction conductivity. ERT inversions were constrained using fixed resistivity regions extracted from downhole induction data. The ERT sections were then interpreted using the 2020 downhole geophysics, along with available borehole lithology logs and groundwater chemistry. A three-dimensional (3D) model mesh was constructed for the AEM inversion and populated with parameter constraints sourced from the ERT inversions and a gradient reference model built from the upper Pierre Shale contact (extracted from 212 boreholes).

Results and Conclusions

AEM inversion results indicated that an elevated electrical conductivity zone, identified in the apparent electrical conductivity AEM data from multiple frequencies, and which initially appeared to be a large brine plume migrating north of the mine, was instead a zone of shallower marine Pierre Shale flanked by relatively thick and approximately north-south trending lower electrical conductivity paleochannels. These lower electrical conductivity paleochannels could be important aquifers and can be considered in future mine management. This study emphasizes the importance of AEM inversions constrained with comparatively high-resolution surface geophysical methods in order to triage potential brine plumes from clays deposited in a marine environment that have naturally high electrical conductivities.

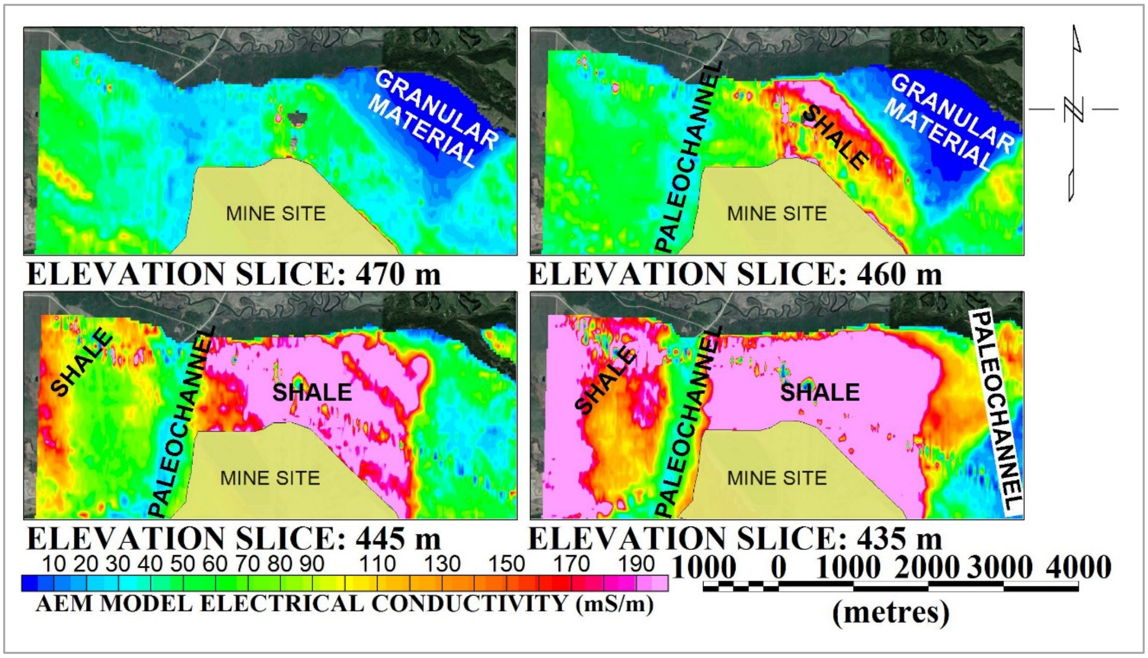

Figure 1. Depth slices extracted from constrained 3D AEM inversion.