Synthesizing 3D Time-Domain Electromagnetic Geophysical Forward Models for Uranium Exploration in the Athabasca Basin

Drew Jones1, Seyyedmasoud Ansari1, Collin Farquharson2, Robert Heares2

1Department of Earth Science, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, 2 Areva, Saskatchewan SK

Background
Modern mineral exploration in the Athabasca Basin (northern Saskatchewan) is often undertaken in areas of deep sediment overburden, looking for small targets up to 500 metres or more below the surface. Due to the high conductivity of the ore bodies and related graphitic fault zones, time-domain electromagnetic (TDEM) surveys are an important geophysical prospecting tool and have led to the discovery of the majority of known uranium deposits in the region.

Model Construction
Recent advances in the 3D forward modeling of frequency-domain EM data using unstructured tetrahedral meshes have shown great promise in more accurately modeling anomalies of complex shapes. Methods now exist for incorporating realistic structural geologic data into these unstructured meshes. A method of using many 3D frequency-domain forward responses in order to construct an accurate 3D time-domain forward response is being investigated in this study for its practical use in more accurately delineating complex, thin, near-vertical conductors and closely related sets of conductors.

Current and Future Work
Current work is focused on creating a set of models that demonstrate a variety of simple conductors with varied thickness, dip, conductivity, shape and position. Work has also begun in creating models that reproduce realistic exploration situations like that seen below based on data obtained from Areva’s Waterbury-Cigar Lake Project. Future work will be focused on incorporating a wider variety of relevant structural data obtained from drill logs, geologic maps/cross-sections, etc. in order to create models that are able to provide better understanding of the complex exploration challenges currently faced by Areva in the Athabasca Basin.

Mesh Refinement
Obtaining a high quality mesh is of utmost importance in order to compute accurate values of the electric and magnetic fields. Mesh quality is dependent on the geometry of the tetrahedral cells and most importantly their dihedral angles. A variety of methods were tested to adequately refine models for the best results in both the frequency and time domains.

Cutaway image of a 3D unstructured tetrahedral mesh with increasing refinement toward center of model; triangular facets are outlined in blue.

Citation:

Acknowledgements
I would like to thank Mathieu Moineau and Patrick Leclaire of Areva for their guidance and support, as well as their sponsorship of this project.