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

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Modern mineral exploration in the Athabasca Basin (northern Saskatchewan) is often undertaken in areas of deep sediment overburden, looking for small targets up to 800 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 Athabasca Basin. 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 also 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 and near-vertical conductors and closely related sets of conductors. Forward modeling is carried out initially in the frequency domain using a 3D finite-element algorithm. Models are computed for one frequency at a time, with the results for many frequencies then combined and transformed to produce a single 3D time-domain response. Obtaining a high quality mesh is of utmost importance in order to compute accurate values of the electric and magnetic fields. A variety of methods were tested to adequately refine the models for the best results in both the frequency and time domain. Three-dimensional time-domain results for simple half-space models have successfully reproduced similarly computed 1D results and the procedure has been deemed adequate to proceed to models containing simple conductors and complex conductive packages in an attempt to create the most accurate 3D time-domain forward models possible. One such model, indicative of a real exploration situation faced in the Athabasca Basin will be presented.