Multi-scale Modelling of the Superior Craton, Canada using a Sequential Inversion Workflow of Magnetotelluric Data

*Eric Roots[1,2], Graham Hill[3,4], Ben Frieman[1], Richard Smith[1], James Craven[2]

1. Mineral Exploration Research Centre, Laurentian University, Sudbury, Canada, 2. Geological Survey of Canada, Ottawa, Canada, 3. Institute of Geophysics, Czech Academy of Science, Prague, Czech Republic, 4. Gateway Antarctica, University of Canterbury, Christchurch, New Zealand

In order to characterise how crustal architecture influences mineralisation processes, Metal Earth is employing magnetotelluric (MT) surveys in the Archean Superior Province over a variety of scales from the craton- (100-1000s of km) to the deposit-scale (10s of km). Insight regarding the link between cratonic structures and economic deposits can be gained through modeling and interpretation of deposit-scale datasets within the context of regional studies; however, the computational cost of inverting such datasets is prohibitively high. The Metal Earth MT data collected throughout the Superior Province offers the opportunity to refine the workflow needed to integrate MT data at a variety of spatial scales. The broadband data used in this study was collected along approximately north-south ~100 km long regional transects with a 5-7 km station spacing. Embedded within the majority of these regional transects are high-resolution, ~10 km long segments that contain broadband and audio-magnetotelluric stations at a spacing of 330 m. These data were combined with existing broadband and long-period MT data from prior regional surveys (e.g., Lithoprobe) to provide broader coverage across the Superior Province. To generate mutually consistent models from the craton- to deposit-scales, a sequential inversion workflow was applied to data from the Western Superior. Long-period data, primarily derived from the Lithoprobe surveys, covering an area of ~325,000 km^2 was inverted to image the broad-scale resistivity structure. Then the transect-scale data were inverted using the regional model as a prior. Finally, phase tensor data from the embedded high-resolution segments were inverted using the transect-scale model as the prior. The resulting models are robust and consistent across the scales of interest. Comparison of these models with those obtained through conventional modeling at each scale demonstrates the importance of constraining smaller scale inversions with regional structure, particularly when dealing with 3-D data collected along quasi 2-D transects. For example, conventional modelling of regional data along the Dryden transect suggested low resistivity zones along the edges of the White Otter batholith, whereas results from the sequential inversion workflow imaged the entirety of the batholith as a resistive body. The low resistivity feature required by the data is instead accounted for by a linear conductor coincident with the Quetico fault, a crustal scale fault separating the volcanic Wabigoon and sedimentary Quetico subprovinces. As plutons are generally expected to be resistive, the model resulting from the sequential workflow provides a simpler and more plausible explanation for the observed data.

Keywords: Magnetotellurics, Inversion, Lithospheric Structure