Kimberlite Exploration Using a Capacitive-Coupled Resistivity System

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Summary

A major source of frustration are spurious EM kimberlite anomalies generated by conductive surficial sediments. The solution is to resolve a 2D image of the target. True resistivity cross-sections are readily generated from CCR (capacitive-coupled resistivity) data. CCR surveys are uniquely suited to resistive northern ground and are rapidly conducted.

Introduction

The Geometrics Ohm Mapper, a CCR system, was tested in the Fall of 2004 in the Northwest Territories on two known kimberlites and three drilled, barren targets falsely identified as kimberlites by other geophysical methods. For each target, a central line was chosen from previous ground geophysics and multiple passes made with dipole lengths from 5 to 20 m and dipole separations from 10 to 240 m. The data is presented as a pseudosection and then inverted to recover a 2D resistivity model with an estimate of the depth of investigation.

Results

This paper presents the pseudosection and recovered resistivity models from the five test targets. In general, the data from the kimberlitic targets persist at depth more than the false targets. As well, drilled overburden depths match well with the recovered overburden thickness. Two examples are shown in this abstract.

Results for CT55, a kimberlite, are shown in Figure 1.The plan map on the left shows resistivity measurement taken with the Rescan, another CCR instrument, with 20 m dipoles and 80 m dipole separation. On the right is gridded total magnetic field data. Above the plan maps is the recovered resistivity model and a pseudosection of the Ohm Mapper data. Resistivity data was collected with dipole separations of 15 and 30 (using 5 m dipoles); 40 and 60 m (using 10 m dipole); 80, 120, 160, 200 and 240 m (using 20 m dipoles).Depth of investigation is based on the difference between high (20 kOhm) and low (200 Ohm) half-space reference models. The overburden thickness in the recovered model is consistent with drill results and the conductive anomaly of the kimberlite persists at depth.

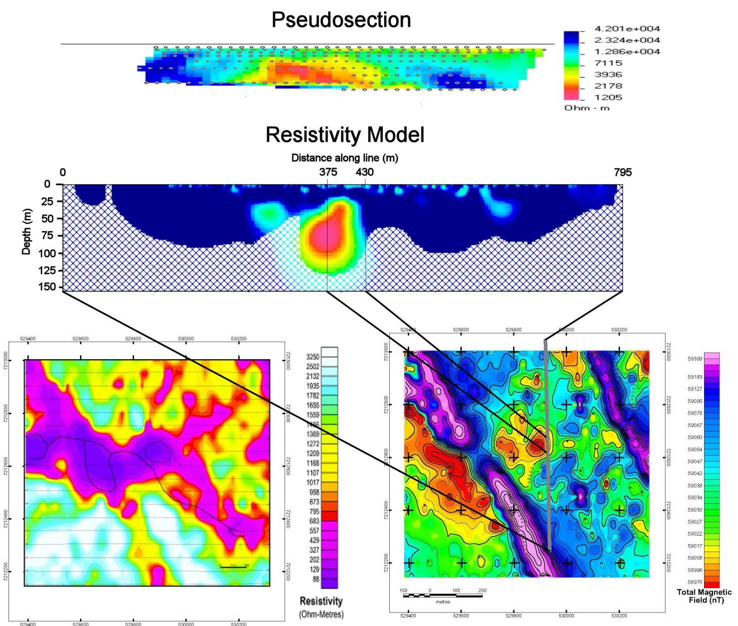

Figure 1: CT55, kimberlite

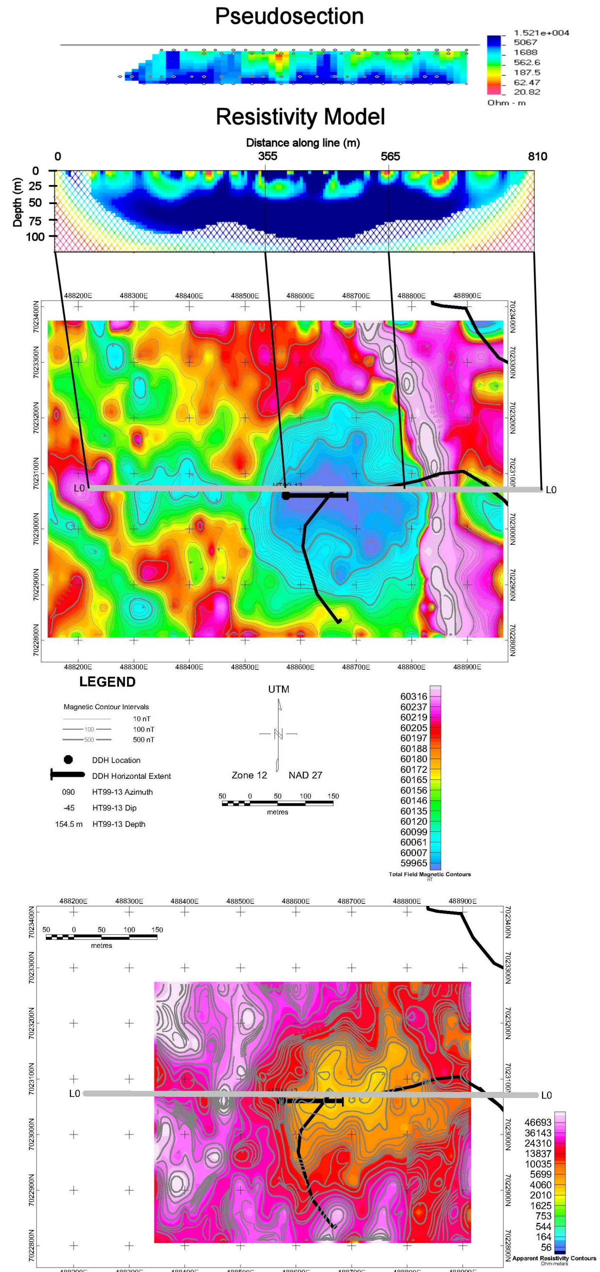

Figure 2: Hilltop area, false target

Figure 2 illustrates a false target from the Hilltop area. The lower plan map shows resistivity measurements taken by the Rescan with 20 m dipoles and 80 m dipole separation. The upper plan map is gridded total magnetic field data. Above the plan map is the recovered resistivity model and a pseudosection of the Ohm Mapper data. Resistivity data was collected with dipole separations of 20 and 40 m (using 10 m dipole); 160 and 200 m (using 20 m dipoles). Depth of investigation is based on the difference between high (20 kOhm) and low (7 Ohm) half-space reference models. The recovered model does is not conductive at depth and does not suggestive a kimberlite. This is a barren target.

Methodology

The unit is towed behind the operator (or snow machine) as a streamer allowing fast and dense data collection. Receiver and transmitter dipole length are adjustable to optimize resolution and depth penetration. An AC current (approx 16.5 kHz) is passed through the transmitting dipole which acts as one plate of a capacitor. The earth acts as the second plate. Because an AC current can pass through a capacitor, the current in the transmitting dipole passes into the ground. Similarly, the voltage is measured at the receiving dipole.

Multiple-dipole data is presented as a pseudosection of apparent resistivity. More useful is a true cross-section of resistivity obtained with the DCIP2D package developed by the University of British Columbia Geophysical Inversion Facility. The data to model inversion has a non-unique solution obtained by minimizing a model norm function subject to fitting the data within the error of the survey. Each iteration must balance the trade-off between the minimization and the constraint. The inversion algorithm is described in detail by Oldenburg and Li (1994). By comparing results obtained using different initial and reference models, an estimate of the depth of penetration can be inferred. Where the two recovered models differ, results are dependent on initial and reference models instead of data and are unreliable. Model results that differ by more than 10% have not been plotted.

Future directions

- With the rapid data collection of the Ohm Mapper, a 3D data set would be economical to obtain and the 3D inversion could yield an unparalleled view of exploration targets.
- If a down-hole resistivity log is performed, this data can be used to further constrain inversion results and aid in delineation drilling.
- A CCR survey can illuminate the facies structure within a kimberlite pipe.

Acknowledgements

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References

Oldenburg, D.W, and Li, Y., 1994, Inversion of Induced Polarization Data:Geophysics. **59.** 1327-1341.