KIMBERLITE EXPLORATION USING A CAPACITIVE-COUPLED RESISTIVITY SYSTEM

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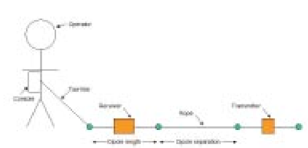
Results from a test of a multi-receiver capacitively coupled resistivity system over known kimberlites and drilled false-anomalies in the Slave Craton, NWT. The test included 2D resistivity profiling using repeated profiles with diffrent dipole separations, the results of which were inverted to yield 2D resistivity models. This new method is now in production in the NWT and Nunavut.

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

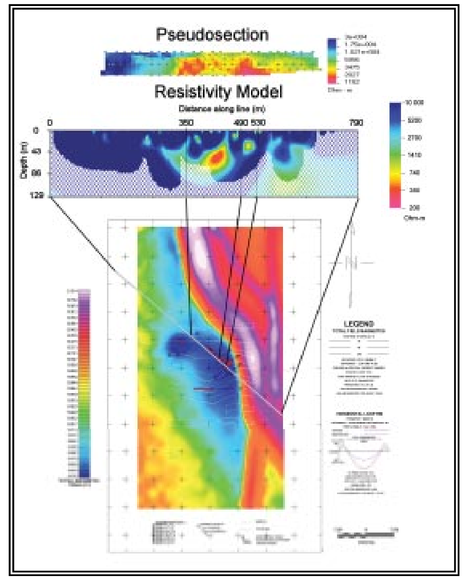
The Geometrics Ohm Mapper, a CCR system, was tested in the Fall of 2004 on three Diamondex targets (CT55, two anomalies on the Carat Property and Hilltop area) and two Diavik targets (A180 and an anomaly in the Lac de Gras area). A180 and CT55 are known kimberlites while the other three anomalies are drilled, barren targets falsely identified as kimberlites by other geophysical methods.

The Ohm Mapper is towed behind the operator (or snow machine) as a streamer allowing fast and dense data collection. Receiver and transmitter dipole lengths 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.



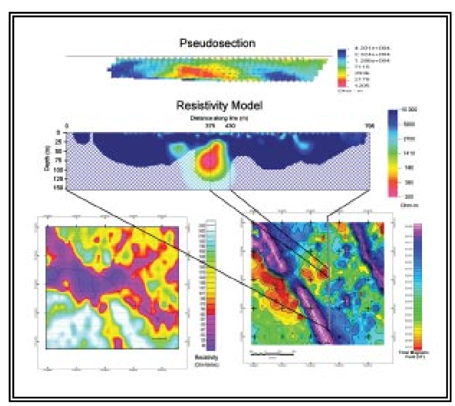
Multiple-dipole data are presented as a pseudosection of apparent resistivity. More useful is a true cross-section of resistivity obtained with the DCIP2D package developed by the University of British Columbia Geophysical Inversion Facility. The data-to-model inversion has a non-unique solution obtained 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.

A180 - Kimberlite



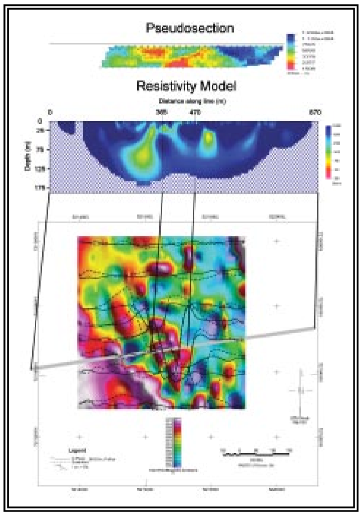
On the plan map are HLEM 28 kHz data using 150 m coil separation overlain on gridded total magnetic field data. The drill traces with kimberlitic intersections are also shown. Above the plan map is the recovered resistivity model and a pseudosection of the Ohm Mapper data. Data were collected with dipole separations of 40 and 60 m (using 10 m dipoles); 80, 120,160 and 200 m (using 20 m dipoles.) Depth of investigation is based on the difference between high (50 kOhm) and moderate (3460 Ohm) half-space reference models. The conductive zone matches the kimberlitic drill traces and the anomaly persists at depth. The modelled depth of overburden agrees with drill results (25-40 m of overburden).

CT55 - Kimberlite



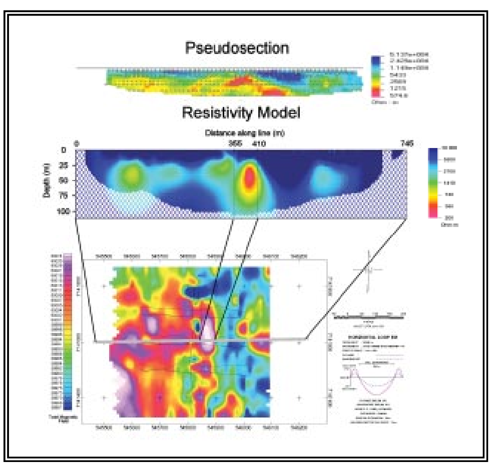
The left-hand plan map plots resistivity measurements taken with the Rescan, another CCR instrument, with 20 m dipoles and 80 m dipole separation. The right-hand plan map is gridded total magnetic field data. Above is the recovered resistivity cross-section and a pseudosection of the Ohm Mapper data. Resistivity data were collected with dipole separations of 15 and 30 m (using 5 m dipoles); 40 and 60 m (using 10 m dipoles); 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) reference models. The overburden thickness in the recovered model is consistent with drill results and the conductive anomaly of the kimberlite persists at depth

Carat Property – False target



HLEM 28 kHz data using 100 m coil separation overlain on gridded total magnetic field data are shown on the plan map. Above is the recovered resistivity cross-section and a pseudosection of the CCR data, collected with dipole separations of 20, 40 and 60 m (using 10 m dipoles); 80, 120, 160, 240 and 280 m (using 20 m dipoles). Depth of investigation is based on the difference between a high (20 kOhm) and low (200 Ohm) half-space reference models. The recovered model does not have a coincident conductive zone with the magnetic high, but shows two modest conductors to the east and west. The recovered model is not suggestive of a kimberlite pipe and this is a barren target.

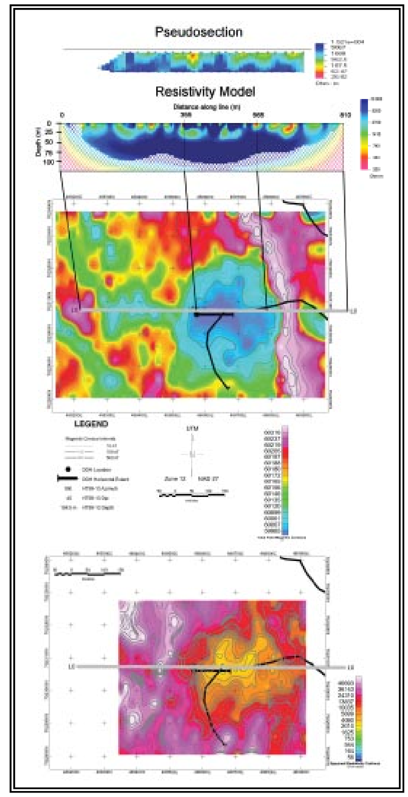
Lac de Gras Area – False Target



On the plan map are HLEM 28 kHz data using 100 m coil separation overlain on gridded total magnetic field data. Above the plan map is the recovered resistivity model and a pseudosection of the CCR data. Resistivity data were collected with dipole separations of 10, 20, 30 and 40 m (using 5 m dipoles); 50, 60 and 120 m (using 10 m dipoles); 80, 160 and 200 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. Drill results (hole at 340 m along the CCR line, bearing of 045) show 2-3% pyrite at 23 m, increasing with depth to 69 m. This is consistent with the recovered model

Hilltop Area - False Target

The lower plan map shows resistivity measurements taken by the Rescan, another CCR instrument, with 20 m dipoles and 80 m dipole separation. The upper plan map 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 were collected with dipole separations of 20 and 40 m (using 10 m dipoles); 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 is not conductive at depth and does not suggest a kimberlite. This is a barren target.



Future directions

- EM coupling is a significant source of noise, especially with large dipole separations. A technique to remove the EM coupling component from the data prior to inversion in under development.
- 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, these 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.

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