Using ERA low frequency E-field profiling and UBC 3D frequency-domain inversion to delineate and discover a mineralized zone in Porcupine district, Ontario, Canada.

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Summary

A low-frequency resistivity survey using ERA electrical profiling (middle gradient array) has been completed over a nickel prospect in Porcupine District, Ontario, Canada. The results of this EM-Resistivity were used to calculate the apparent resistivity and were further inverted using UBC-GIF 3D Frequency Domain Inversion Software, EH3DInv. The results of the inversion have shown the anomalous distribution of electrical properties, consistent with a known geological contact between metavolcanic rocks and an ultramafic pluton. The conductive zone has been interpreted to be located in the interval between 70 and 120 meters.

The interpreted conductive zone was further subjected for a drilling program. The drilling program was carried out in March-April 2011 and revealed a 21m thick zone with disseminated to massive mineralized intervals starting at 82 meters, which is consistent with the results of 3D inversion of ERA data.

Introduction

The area under study is located in Porcupine Mining District, approximately 40 km North of Timmins, ON (Figure 1).

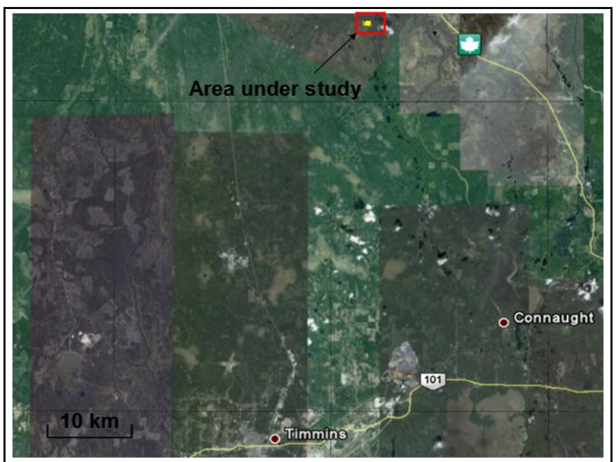

Figure 1. Geological setting of area under investigation.

The Porcupine Mining Area is a region in Northern Ontario with an established record for gold and nickel prospecting. There are historic geophysical and drilling data available, including Total Magnetic Intensity surveys, airborne Time Domain surveys (Geotem) and geological data (1:250000 scale). The prospect subjected for detailed ground surveying with ERA is situated on a contact between an ultramafic pluton and a metavolcanic complex (Figure 2).

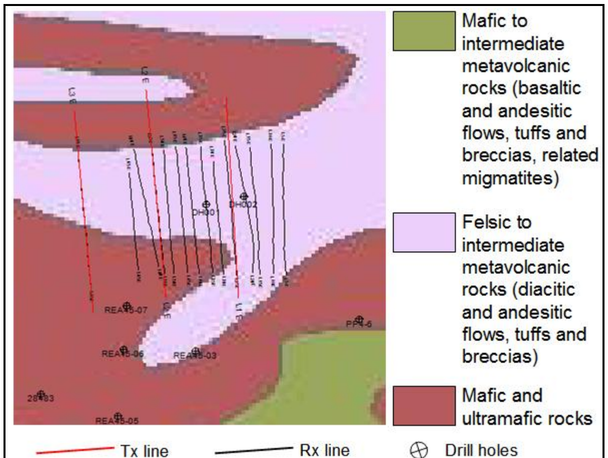

Figure 1. Geological setting of area under investigation.

This setting is very favorable for nickel mineralization and furthermore, the historical geophysical data has been showing indication of a conductive zone with an E-W trend. The ground geophysical survey was further conducted for increased resolution and to plan a drilling program.

ERA profiling methodology

ERA is a geophysical system, which can be employed for various types of DC and EM surveys, including E-field measurements using non-grounded transmitter-receiver geometries (Sapozhnikov, 2001), as well as grounded transmitter electrode arrays and grounded receiver electrode arrays (similar to DC resistivity measurements, but carried out in presence of low-frequency AC). Such measurements, when done at low frequency allow to minimize the inductive coupling of the transmitter and at the same time increase the penetration depth and signal to noise ratio of the system (Koralow et al, 1996)

The measurements are voltage amplitudes on the receiver array, which are further converted into units of apparent resistivity using equation (1):

(1) $\rho_a = K*I*|U_{MN}|$

where ρ_a is the apparent resistivity, K is the geometrical coefficient of the array (similar to DC resistivity calculations), I is the current strength (A) and $|U_{MN}|$ is the absolute difference of potentials on the receiver electrodes (V).

This equation is generally derived for DC resistivity arrays; however, it can be used as an approximation for low frequency measurements (Figure3)

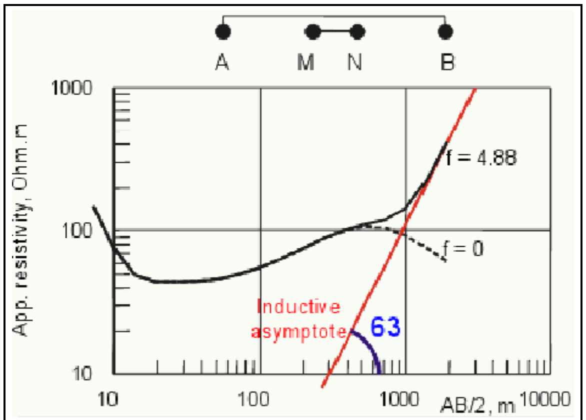

Figure 3: Apparent resistivity of half-space calculated for DC (0 Hz) and low-frequency AC (4.88 Hz). Adapted from Bobachev, 2006.

The penetration depth for this method is not only a function of the transmitter electrode separation, but is also achieved as a result of very low system noise due to specifics of the survey configuration. For mining applications the depth of investigation becomes increasingly important. It is therefore recommended to use low frequency measurements, which allow to measure high range of electrical properties with relatively low noise and also minimize the inductive coupling with the transmitter (Kolarow et al, 1996).

The survey

The survey was carried out with 50m line spacing, using 3 1 km transmitter lines and 12 receiver lines, 800 m each (Figure 2). Current used for the survey was 0.1 A and was delivered to the grounded transmitter line at frequency of 4.88 Hz. Upon completion of the survey, the apparent resistivity map was constructed and combined with the historical magnetic data available for the area under study (Figure 4).

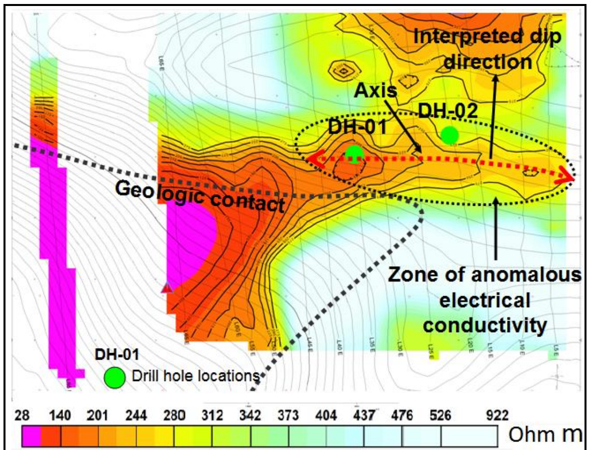

Figure 4: Apparent resistivity calculated from ERA data. Gridded apparent resistivity is plotted over the Total Magnetic Intensity contours.

The zone of anomalous electrical conductivity shown in Figure 3 appears to be a down-dip continuation of the ultramafic pluton, which is at the same time consistent with the rapid change in Total Magnetic Intensity, marking the geologic contact. Based on this interpretation two drill holes (DH01 and DH02) were planned. DH01 appears to be consistent with the axis of the anomalous zone, while DH02 is located down-dip from the axis.

3D Inversion

In order to estimate the depth to the potential mineralized zone and to produce better recovery of the conductive zone, a 3D inversion was implemented using the UBC-GIF program EH3DInv for frequency-domain inversion over 3D structures (Haber et al, 2000; Haber et al, 2004; Oldenburg et al, 1998).

The mesh used for the inversion was composed of 50 20m cells in northern direction; 50 20m cells in eastern direction and 54 10m cells in vertical direction (135,000 cells in total). The inversion was performed for multiple transmitters at a single frequency (4.88 Hz). The total number of data, participated in the inversion was 399.

The convergence curve for the inversion is shown in Figure 5. The predicted data was used to produce apparent resistivities according to equation (1) and these apparent resistivities were plotted in comparison with the apparent resistivities derived from the field data (Figures 6a and 6b)

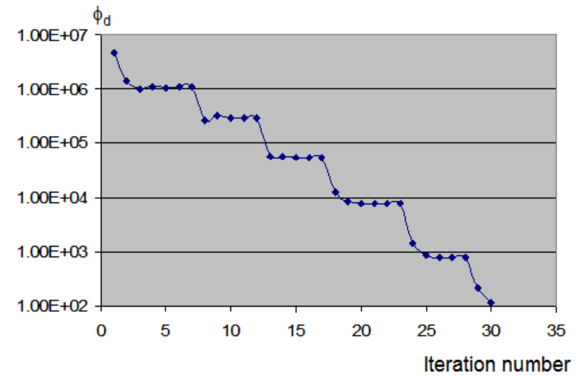

Figure 5: EH3DInv convergence for a 3 transmitter single frequency inversion.

The inversion resulted in recovery of electrical conductivity distribution over the extent of the mesh. The interpretation of the results is suggesting that the depth of the overburden is 20 to 30 m, while the depth to the top of mineralized zone is between 70 and 90 meters, depending on the conductivity cut-off value (Figure 7a). These interpretation results in combination with a-priori information were used for planning of a drilling program.

As the drilling is currently an on-going venture, DH02 has reached the bottom of the overburden at 31m and has been recently reported to have intersected a mineralized zone starting at the depth of 82 meters and traced to the depth of 103 meters. As the drilling operation continues it is expected that the intersected mineralized zone to be extensive to greater depth, in accordance with the 3D inversion results.

Figures 7b and 7c are showing the depth slices at depths of 100 m and 120 m respectively. These figures confirm the prior interpretation of N-dipping mineralized zone, and suggest the continuation of the drilling program, with accordance to the results of ground geophysics and 3D inversion.

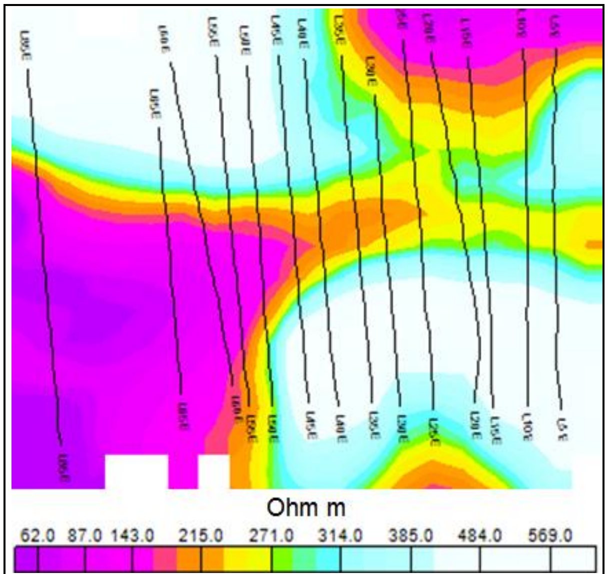

Figure 6a: Predicted apparent resistivity (EH3DInv)

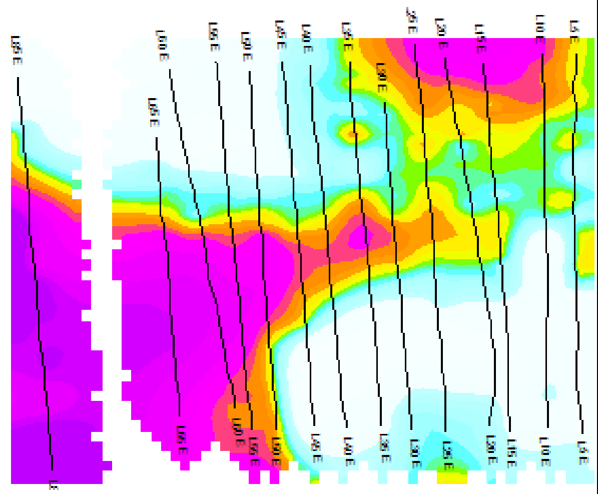

Figure 6b: Apparent resistivity calculated from the field data.

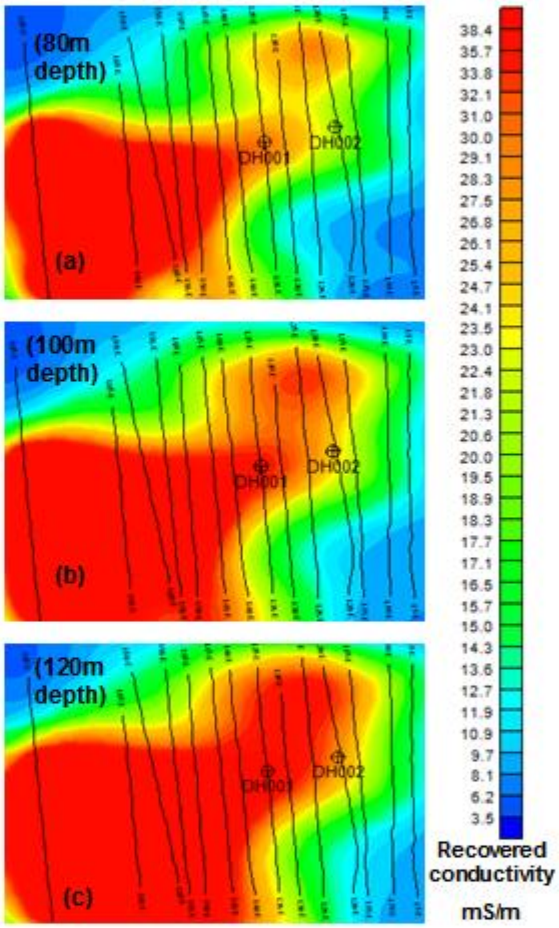

Figure 7. Depth slices based on EH3DInv 3D inversion results: (a) Depth = 80m, (b) Depth = 100m, (c) Depth = 120m

EDITED REFERENCES

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