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Visualization and Analysis of Multi-Parameter Geophysical Data to Delineate Subsurficial Geology

Alzbeta Ondercova[1], Alex Furlan[2], Hernan Ugalde[2], Bernd Milkereit[1]
[1]University of Toronto, [2]Brock University

Summary

Geophysical survey methods are useful for identifying physical rock properties, which allow to deduce information such as lithologies and structures present in the subsurface. Another advantage is that they are capable of collecting this information without direct contact with the material of interest. This is highly applicable in the mineral exploration field in areas that are inaccessible due to topography or vegetation, and where there are limited outcrops and obtaining samples poses a significant challenge. In such cases, airborne geophysical data can give a better understanding of the physical properties of the materials present. Advancements of technology have also allowed the collection of large amounts of data in short periods; however, one significant challenge that is still faced when working with geophysical data is the problem of non-uniqueness of the number of models that can satisfy the data (Ellis, 2010). This issue highlights that with limited data, there is an infinite number of subsurface property distributions that can create an identical response. However, it is possible to constrain the models by introducing available geologic data to reduce the number of possible solutions (Barbosa & Silva, 2006). Another possible way to constrain a model is to use coincident data of a different property, allowing us to draw a better-refined conclusion from our geophysical datasets. This multi-parameter analysis can be done by various approaches: joint inversion (Li & Oldenburg, 2000) or statistics. To view the relations between datasets, we propose the creation of visual multiple parameter models that allow the display of many different physical properties that are geospatially coincident, thus facilitating the identification of correlations.

Introduction

The area of study is a Devonian rift in northern New Brunswick. This area is currently under exploration for base metals and is covered in dense vegetation, forested areas and swamps, which limits the visible geologic outcrops. Several different geophysical methods have been applied to delineate sub-surficial geology. Over several years, we have accumulated an extensive database of geophysical data using a range of methods. These include various airborne and ground methods such as chargeability, induced polarization, resistivity, magnetics, electromagnetics, radiometric, LIDAR, seismic, self-potential as well as petrophysical and geochemical data obtained from drill cores. Although we have a range of geophysical datasets available, most analyses up to date have been done on individual physical parameters, which requires multiple separate interpretations. This limits our ability to identify patterns and trends in the data. Using a combination of datasets together can provide the ability to analyze similarities instantly and ensure greater confidence in our conclusions. In this project, we propose that it may be possible to view multiple near-surface geophysical datasets simultaneously in one visual map to create a more efficient and effective visualization tool, interpretation and analysis. The extensive geophysical dataset over Nash Creek, as well as the large petrophysical database, derived mostly from the numerous boreholes drilled in the area, provide an extensive geological and geochemical database that we can use to validate results from our multi-parameter visualization. This new geospatial visualization map results in a probabilistic geology map that is created from the geophysical data.

Method

Our study begins in a small localized (~4 km^2) area with a sufficient amount of geospatially correlated data for shallow (~20m) depth beneath overburden. We begin using three parameters: magnetics, from an airborne magnetic survey, inverted chargeability and resistivity from a pole-dipole DC/IP survey, using a ternary RGB colour scheme. The scales of the data for each parameter were converted into 256-byte scales to ensure consistent ranges to create these visualizations. Each parameter was then assigned a colour. Once displayed in the multi-parameter visualization, we can identify patterns that begin to occur and see areas where each parameter begins to dominate. Based on the three values at a given location, we will be able to associate with a colour or a colour range with a lithology with similar expected properties. The extensive petrophysical database, developed from drill core, borehole geophysics and lab study data, of approximately 300 legacy boreholes, allows us the opportunity to verify the observations found in our geophysical surface maps and identify distinct patterns. Three unique patterns include (1) mafic intrusion with extremely high magnetic response, high resistivity and low chargeability, (2) mafic dyke with elevated magnetic response, high resistivity and low resistivity and (3) hydrothermal alteration and mineralization with low magnetic and resistivity but high chargeability response (Bongajum et al., 2009). Low responses in all three parameters are found in sediments. Ultimately, when we apply these

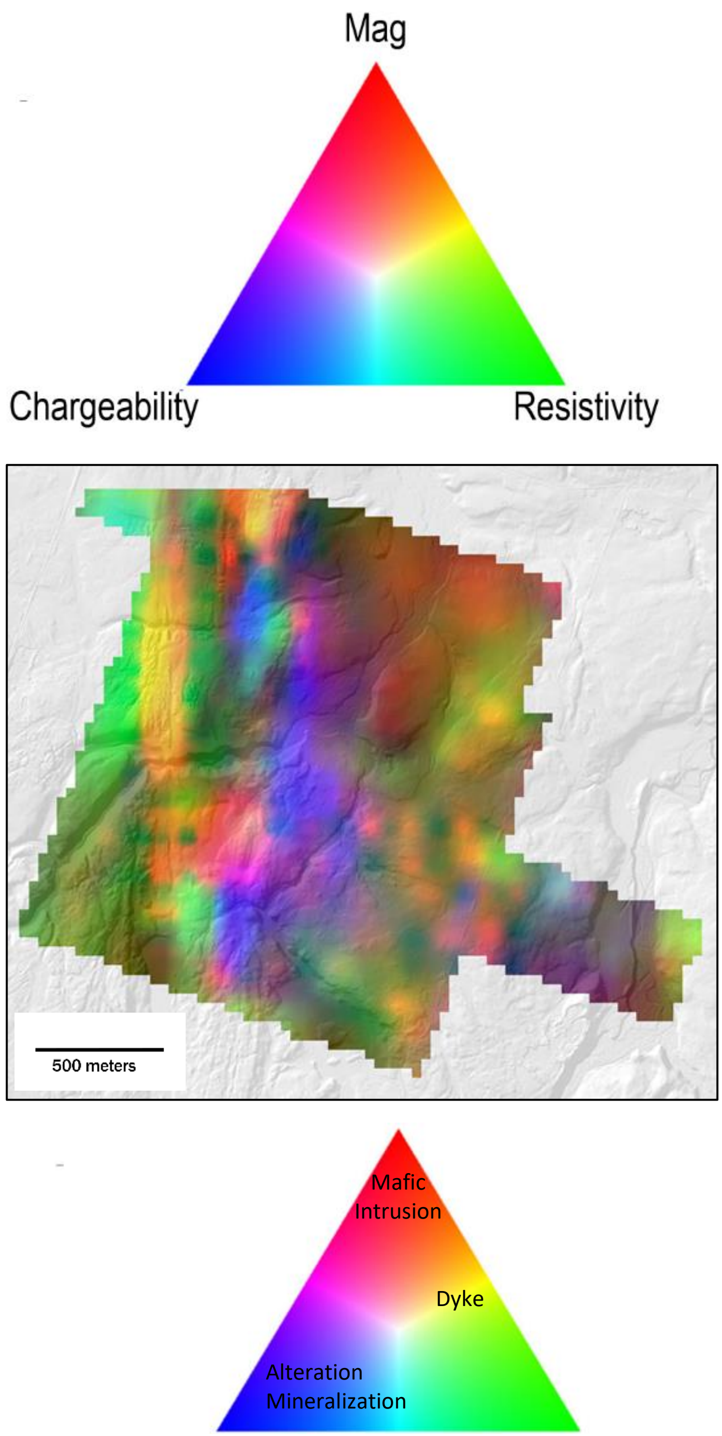

Figure 1: A sketch of the ternary colour scheme used for the creation of the multi-parameter visualization (top).The result preliminary multi-parameter visualization of the magnetics, chargeability and resistivity dataset (middle). Probable geologic features and lithologies associated with the different resulting colours (bottom).

geologic constraints from our petrophysical database, we can identify and delineate probable lithologies.

Conclusions

The preliminary result shows a promising look into how it is possible to display multiple parameters in one geophysical image and draw conclusions from it. The next steps would be to assign various colours from our ternary plot to different lithologies known to be present and create a geological probability map. It is, however, important to keep in mind that we are only able to identify lithologies in this area because of the petrophysical data from drill cores in the area, allowing us to constrain our geophysical maps. Interpretations would otherwise be hard to justify due to the lack of outcrops in the study area. Another limitation of this project is the need for high resolution sampling and sufficient amounts of geospatially coincident data. Ultimately, the creation of a multi-parameter visualization tool would result in the ability to visualize and analyze several different parameters at once, thereby significantly reducing the time needed to analyze geophysical data sets. This model will optimistically have the ability to identify various geologic structures and lithologies in the subsurface with applications for mineral exploration. These models could then possibly be used to identify mineral deposit exploration targets with greater accuracy allowing for more confident drilling targets and more successful exploration projects.

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