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Building 3D Density Models for Exploration

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Summary

The study focuses on density measurements retrieved on drill core in northern New Brunswick. The large amount of densely spaced boreholes presents a unique opportunity for correlating physical rock measurements for better three-dimensional density modelling results. We also want to investigate the efficiency of a new method for evaluating density variations for sulfide mineralization with the use of portable X-Ray Fluorescence (XRF) analysers.

Introduction

Conductivity, porosity, velocity, permeability, and density are all parameters that are crucial in determining fundamental geological structures that are strongly tied to exploration. Consequently, the dependency of petrophysical data on geological interpretation leads to a vast interest in the field of geophysical exploration. This study will focus on density properties as a mean to evaluate mineralization and alteration zones. To be more precise, density will be examined as a component for mineral exploration and construction of infrastructures for open-pit mining. The site under investigation within this study is in Nash Creek, New Brunswick. This property has a huge database of information, which originates from an impressive amount of drill core in the area. A complete three-dimensional density model will be made by applying an inversion to the observed data. We will then investigate the efficiency of portable XRF spectroscopy and if they can be used as a proxy for density.

Theory

Previous research has examined the correlation between density and mineralization patterns. Alteration zones strongly correlate with lower density values. Consequently, when boreholes intersect high grade sulfide zones, densities reach higher values (Bongajum, 2013). Hence, the analysis of density measurements has proven to be successful in finding mineral-rich zones.

A three-dimensional density model will be derived from petrophysical measurements obtained from drill core. Each borehole is provided with density measurement, which will be the focus in this study. We will use the three-dimensional linear inverse method to construct the three-dimensional density model. We will also evaluate portable XRF as a source to derive density logs. Since density has been recognized as being tied to mineralization and alteration zones, an opportunity arises in discovering innovative and economically-driven alternatives rather than using radiation sources. Portable XRF spectroscopy and spatial variation relative to density measurements of the Nash Creek site will be investigated to find alternative sources where density can be derived. To understand how XRF may be used as a logging tool, it is important to understand that mass density is primarily dependent on the specific number of atoms that is contained within a rock sample (Schmitt, 2003). The use of XRF spectroscopy is a technique which has been used in many different fields. This element specific spectroscopic technique has been proven to be a valuable tool in metal-rich environment, since it is most effective to measure heavier elements. This technique is applicable to all types of sample independent to the natural physical state and is still detectable down to micro-concentrations. XRF provides element based information for multiple composites (Hummer & Rombel, 2013). Its efficiency to detect base metal elements has been proven to be adequate, yet the investigation on whether it can adequately predict densities is still under investigation.

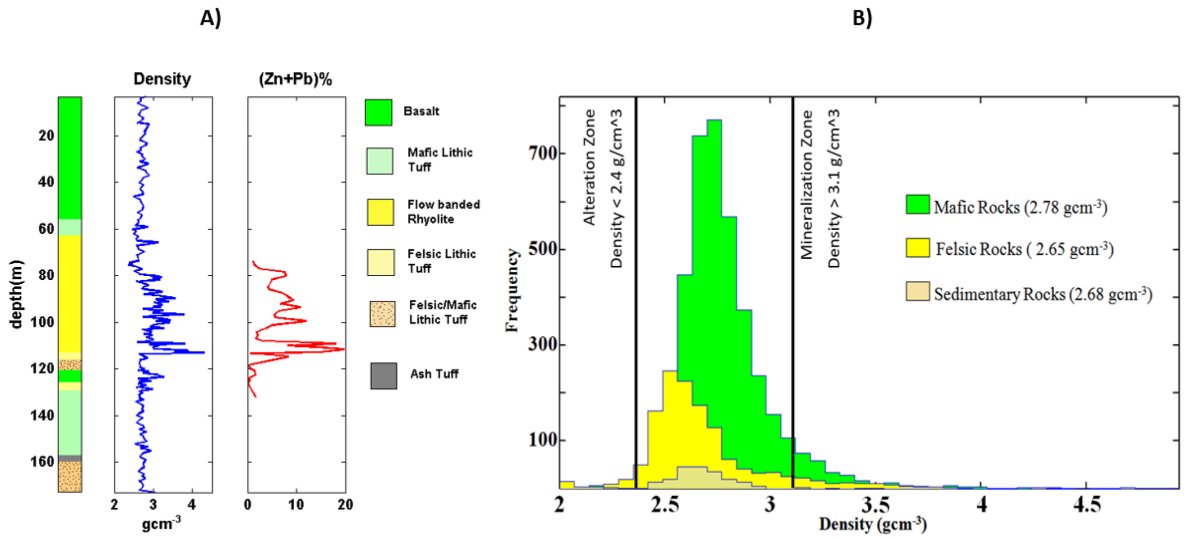

Figure 1 A) Both density and assay log show similar trends (as the percent of lead and zinc increases, the density also increases). Stratigraphic column demonstrates higher densities occur where flow banded rhyolite is located. B) histogram of density values for each rock type. Modified from Bongajum (2013).

Examples

For exploration purpose, a simple workflow process is implemented to build a complete three-dimensional model. The method that will be used will allow us to determine with better precision density variations due to mineralization and alteration occurrence. A median filter has been applied to the density logs to map out only the overall trend of density variations with increasing depth. Due to densely spaced boreholes, interpolation may be used in the initial stage of the inversion. A two-dimensional slice has been set as an example along a profile which contains a large amount of closely spaced boreholes (Figure 2). A large density dataset along with borehole locations is available from previous research (Bongajum, 2013). This accessibility enables to deepen our research for investigating density implications in the field of mineral exploration.

For better geological interpretation for evaluating density variations, a larger density dataset is required. To do so, a new method is presented in this study. Portable XRF spectroscopy properties are explored and tested to investigate if it can be a reliable alternative for density measurements. To determine the effectiveness of portable XRF data in the field, large scale data acquisition was made using a portable XRF instrument. X-ray fluorescence spectroscopy values has been retrieved from multiple drill core samples. From this dataset, investigation regarding its repeatability of the values has been made. This enabled us to justify its degree of success. From these results, this part of the study will investigate if XRF data has the potential to be used as a proxy for density measurements in the context of mineral exploration. This will be done by taking multiple samples along each retrieved core and building a density log from the XRF measurements. By deriving a proper algorithm, density at varying depth will be derived by using the XRF spectrum of different samples (Figure 3). This concept will address the compatibility of

XRF technology with density models enhancing geophysical exploration techniques. The spectrums in Figure 3 are examples of the obtained results. These XRF spectrums demonstrate repeatability (i.e. effectiveness) of the XRF instrument as all five trial for each sample have good correlation. Finally, alternation and mineralization zones will be identified by observing density variation from the results.

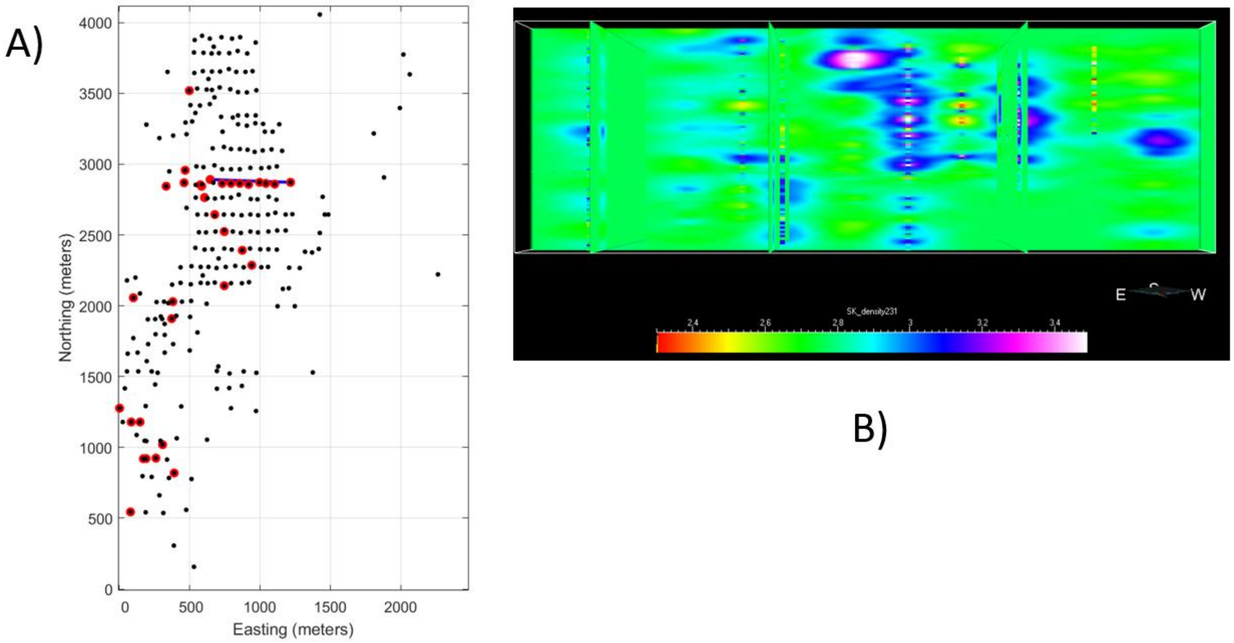

Figure 2 A) Map of all borehole locations (black) as well as density logs retrieved on some of them (identified as red). The line (blue) represents the data collected for the inversion 2D density slice. B) 2D density slice obtained through inversion. The profile is represented by the surface line (2A). Retrieved from Bongajum (2013).

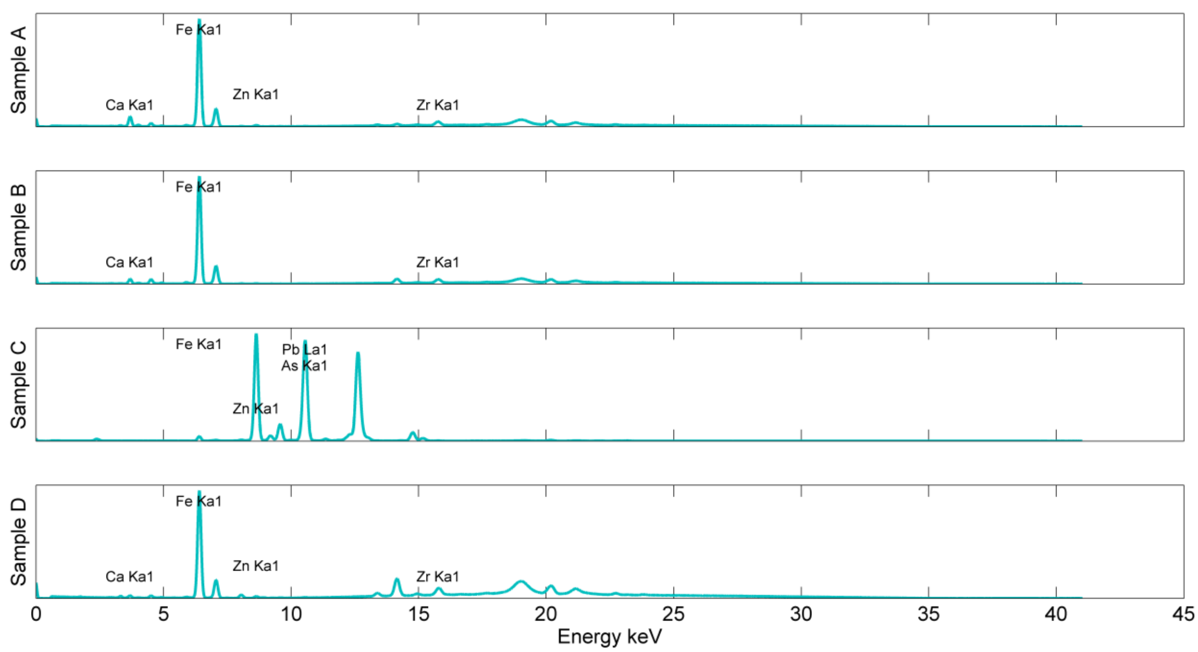

Figure 3 XRF spectrum of different samples retrieved from different cores. These measurements have been made. These samples were taken from different cores at different depths. Repeatability of the data has been measured and identified.

Conclusion

By investigating density variations in the subsurface, mineralization and alterations zones, can be identified. This is particularly useful for mineral exploration, as well in the mining industry. Identifying these patterns enables geoscientists to deduct important information for exploration and exploitation purposes. Hence, through inversion, it is possible to make suggestions on mining development. Also, by evaluating x-ray fluorescence spectroscopy to be used as a proxy for density, this presents an opportunity for a new surveying method to be developped, which can be efficient and cost-worthy.

Acknowledgements

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