Applied Data Analytics on Multi-element Geochemistry for Pre-mining Characterization of Geological and Geometallurgical Attributes: Examples from the Rosemont Cu-Mo-Ag Skarn Deposit, Tucson, Arizona

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Abstract

Planning mining operations involves the characterization of numerous qualitative and quantitative variables such as stratigraphy, alteration facies, oxidation stage, ore grades, specific gravity, metal recoveries, hardness, deleterious minerals, ore types, etc. These variables are commonly characterized on drill core samples to assess the economic feasibility of potential mining operations. However, very often some of these critical variables, for instance quantitative mineralogy and metal recoveries, are limited to <5% of the total available drill core samples. Also, some variables are less reliable, for example visual estimation of mineralogy and discrimination of lithology in metasomatized rocks. In contrast, multi-element geochemical data is reliable and routinely collected in the majority of drill core samples. These characteristics make chemical elements ideal predictor variables to model geological and geometallurgical properties; given that ore forming processes result in distinctive geochemical attributes and constrain the engineering of ore extraction.

To circumvent problems arising from either poor reliability of visual geological determinations or limited number of geometallurgical measurements, this study systematically illustrates different data analytics methods applied to 4-acids multi-element geochemical data obtained from drill core samples of the Rosemont Cu-Mo-Ag skarn deposit. First, a lithogeochemical and chemostratigraphic model was built using hierarchical cluster analysis on compositional variables, principal component analysis, and centred ternary diagrams. Second, predictive models were developed to map skarn alteration facies in the 3D geospace using geochemical variables as inputs and quantitative mineralogy, QEMSCAN and XRD, as training outputs. Ten-fold cross-validation indicates that random forest and linear discriminant analysis are the best predictive models and outperform visual identification of skarn facies. Third, cross-validated classification and regression trees (CART) were used to identify the most relevant geochemical, mineralogical, and metallurgical variables affecting metal recoveries. The CART model recognizes 5 relevant ore types within the Rosemont deposit.

The geochemical data analysis presented here demonstrates that stratigraphy has a strong control on metal grades, and that metal recoveries and ore types are strongly controlled by both stratigraphy and alteration processes. However, geochemistry is neither a substitute for geological and metallurgical variables, nor a solution for undertested properties. Instead, applying data analytics to integrate geochemical inputs with geological and geometallurgical outputs is a powerful tool for establishing the link between ore forming processes, ore extraction, and mitigation of economic risks.