Molar Element Ratio Analysis of Lithogeochemical Data:  
A Toolbox for Use in Mineral Exploration and Mining  

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ABSTRACT

Over the last half century, lithogeochemical data analysis has evolved substantially, and a number of useful quantitative tools are now available to the explorationist to facilitate a variety of exploration tasks. Today, many mining companies are using lithogeochemistry as ground truth to assist explorationists in regional-to-property scale mapping, and drill core logging. However, lithogeochemical data are also capable of being used to classify rocks, and assist in a number of other tactical and strategic exploration activities, including: correlation of stratigraphy on cross-sections, mineral mapping, development of mineral zoning models in plan and section, determination of host rock geochemical affinity and depositional environment, understanding the genesis of both host rocks and mineral deposits, and identification of precipitation mechanisms for mineralization. Clearly, lithogeochemical data analysis is now making substantial contributions to mineral exploration efforts.

Molar element ratio analysis is one of the principal methods used by explorationists today to evaluate lithogeochemical data. This approach is one of many that avoid the effects of closure, the constraint that element concentrations sum to unity, and thereby adds mathematically induced variance to lithogeochemical data that obscures the effects of rock-forming processes. However, the real advantage of molar element ratio analysis is that it examines data in a molar context, allowing investigation of rock compositions in terms of the minerals comprising the rocks. Molar element ratio analysis consists of four basic tools that provide substantial insight into the lithogeochemistry (and mineralogy) of the rocks under investigation. These tools consist of: (i) conserved element analysis, (ii) Pearce element ratio analysis, (iii) general element ratio analysis, and (iv) change of basis rock classification. Conserved element analysis is useful in creating a chemostratigraphic model for the host rocks to mineral deposits, whereas Pearce and general element ratio analysis are primarily used to investigate and quantify the extent of processes that formed the host rocks and mineralization. Change of basis rock classification converts element concentrations into mineral concentrations, allowing lithogeochemical data to be interpreted in terms of minerals and used to provide proper names to rocks, an important activity because of the implications that rock names have on genetic processes and mineral deposit models.

This paper provides a review of the theoretical foundations of each of these four tools, and then illustrates how these techniques have been used in a variety of exploration applications to assist in the exploration for, evaluation and planning of, and the mining of mineral deposits. Examples include the evaluation of lithogeochemical datasets from mineral deposits hosted by igneous and sedimentary rocks and formed by hydrothermal and igneous processes. In addition, this paper illustrates a more recent geometallurgical application of these methods, whereby the mineral proportions determined by the change of basis rock classification are used to predict rock properties critical to resource evaluation, mine planning, mining, and mine remediation.