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Genetic Programming Applied to Base-Metal Prospectivity Mapping in the Aravalli Province, India

Christopher Lewkowski (1), Alok Porwal (2), and Ignacio González-Álvarez (3)

(1) Ncode Pty Ltd, Perth, Australia (chris.lewkowski@gmail.com), (2) Western Australian School of Mines, Curtin University of Technology, Bentley, WA 6102, Australia (aporwal@cyllene.uwa.edu.au), (3) Centre for Exploration Targeting, School of Earth and Environmental Sciences, University of Western Australia, WA 6009, Australia (i.gonzalez.alvarez@gmail.com)

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Mineral prospectivity mapping of an area involves demarcation of potentially mineralized zones based on geologic features associated with the targeted mineral deposits. These features are sometimes directly observable and mapped; more often, their presence is inferred from their responses in various geoscience datasets, which are appropriately processed, generally in a GIS software environment, to derive their spatial proxies, also called predictor maps layers. Most approaches to mineral prospectivity mapping use mathematical models to approximate the relation between predictor map layers and the presence (or absence) of the targeted mineral deposits and to label unique combinations of spatially coincident predictor map layers as mineralized or barren. Essentially, the procedure involves recognizing and distinguishing the patterns of predictor map layers associated with mineralized locations from those associated with barren locations.

Machine learning algorithms such as neural networks, support vector machines, and Bayesian classifiers are highly efficient pattern recognizers and classifiers. They are being increasingly applied to mineral prospectivity mapping, within or outside a GIS environment. However, most of these algorithms have a black-box-type implementation, that is, the output of these models do not generate new conceptual geological knowledge about the relative importance of various variables and their mutual relationships.

Genetic Programming (GP) is a category of machine learning algorithms that address this problem effectively. In addition to generating the output classification map, GP also generates a set of rules that reveal the mutual relationships of the predictor variables, based on empirical analyses. These rules can be used to validate conceptual knowledge against empirical data, and also reveal new patterns in the data, resulting in new conceptual knowledge. This study demonstrates the efficiency of GP for prospectivity mapping of base-metal deposits of the Aravalli province, northwestern India.