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Performance of Predictive Supervised Classification Models of Trace Elements in Magnetite for Mineral Exploration

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Magnetite is a reliable indicator mineral for exploration because it records petrogenetic processes and discriminates deposit types. Binary discriminant diagrams have limits to accurately predict deposit types (prediction accuracy ~40%). This study aims to determine the best predictive supervised multivariate classification method using the geochemical composition of magnetite in order to provide a model usable by industry for mineral exploration and by government for resource assessments. After screening a worldwide database of ~30k magnetite analyses, ~17k observations are selected for study. These data are from 303 different deposits that belong to nine major deposit types (BIF, Fe-Ti, IOCG, IOA, Ni-Cu-PGE, porphyry, VMS, skarn, V) and a variety of unmineralized rocks aggregated in the class “country rocks.” We tested three most supervised machine learning algorithms (Naive Bayes, K-Nearest Neighbor, Random Forest) with two open-source statistical computation platforms: Orange and R. The Random Forest (RF) algorithm yield the best predictive outcome on untransformed data, with prediction accuracies of 80% with Orange and 81% with R. In R, classification precision is always higher than 70%, reaching 94% for Fe-Ti deposits. We tested our RF model on three case studies: 1) IOCG-like deposits, 2) China porphyry Cu-Au and Cu skarn, and 3) Scandinavian Ni-Cu-PGE deposits. Our model was able to effectively predict the deposit type for the first two case studies to the large families of porphyry/skarn and IOCG/IOA. For the third case study, almost 61% of the observations were correctly identified as belonging to Ni-Cu-PGE deposits. To obtain the best prediction statistically, it is essential to analyze the largest number of magnetite samples possible. The RF model developed in this study is accurate enough to be used with confidence for mineral exploration for these nine deposit types. Future work includes a continuous update of the magnetite chemistry database as well as the development of new models based on other indicator minerals to strengthen model predictions and cover a wider number of deposit types.

Figure: A) Spatial distribution of magnetite data according to the deposit type. B) Prediction accuracies for magnetite composition for three studied algorithms using R.