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Classification of different skarn deposits based on the compositional variability of associated grandite garnets: a data science and Machine Learning approach

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Rapid technological improvements made in in-situ analysis techniques, including LA-ICPMS, have transformed the field of analytical geochemistry. This has a far-reaching impact for different petrogenetic and ore-genetic studies where minute major and trace element compositional changes between different mineral zones within a single crystal can now be demarcated. Minerals such as garnet although robust are quite sensitive to the changing P-T and fluid conditions during their formation. These minerals have become powerful tools to characterize mineralization types. Previously, Meinert (1992) has used in-situ major element EPMA analysis results to classify different skarn deposit based on the end-member composition of hydrothermal garnets. Alternatively, Tian et al. (2019) used the garnet trace element composition for the similar purpose. However, these discrimination plots/ classification schemes show major overlap in different skarn deposits, such as Fe, Cu, Zn, and Au. The present study is an attempt to use machine learning approach on available garnet data to found a more potent classification scheme for skarn deposits, thus reaffirming garnet as a faithful indicator for hydrothermal ore deposits. We have meticulously collected major and trace element data of Ca-rich garnets, associated with different skarn deposits worldwide from 40 publications. This collected data is then used to train a model for fingerprinting the skarn deposits. Stratified random sampling method has been used on the dataset with 80% of the samples as test set and the rest 20 % as training dataset. We have used K-nearest neighbour (KNN), Support Vector Machine (SVM) and Random Forest algorithms on the data by using Python as a platform. These ML classification algorithm performs better than the earlier existing models available for classification of ore types based on garnet composition in skarn system. Factor importance is calculated that shows which elements play a pivotal role in classification of the ore type. Our results depict that multiple garnet forming elements taken together can reliably be used to discriminate between different ore formation settings.