

Annonce : Soutenance de thèse

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Heure : 12 oct. 2023 14:00 America/Toronto

Trace element composition of chalcopyrite:

Its potential as an indicator mineral and implications for mineral exploration

Chalcopyrite is a Cu-Fe sulfide found in a wide diversity of mineral deposits. Its trace element composition is highly variable. The crystal structure, the partition coefficient (chalcopyrite-liquid, chalcopyrite-co-crystallizing minerals), and the composition of magma/fluid are major factors controlling the trace element content in chalcopyrite, which reflects the physicochemical conditions of geological environment of formation. These characteristics, as well as its physical properties, make chalcopyrite a potential indicator mineral for exploration.

In order to determine geochemical criteria enabling the use of chalcopyrite as an indicator mineral, samples from 8 deposit types worldwide, including 2 magmatic (Ni-Cu sulfide and Reef-type PGE) and 6 hydrothermal (porphyry, volcanogenic massif sulfides (VMS), iron oxide-copper-gold (IOCG), skarn, epithermal gold and orogenic gold), are analysed. The data are investigated with univariate, bivariate and multivariate statistical methods to characterise its variation in the different deposit types, which combined with the machine learning, enable the development of discrimination models in order to determine the provenance of chalcopyrite.

This study shows that the most important difference in trace element composition of chalcopyrite is observed between magmatic and hydrothermal systems. According to our results, Ni determines this difference, with values significantly higher in chalcopyrite formed in Ni-Cu sulfide and Reef-type PGE deposits than in hydrothermal deposits. In magmatic systems, the trace element composition of chalcopyrite is principally controlled by magma/sulfide liquid ratio (R-factor) during crystallisation, enabling the discrimination between Reef-type PGE and Ni-Cu sulfide deposits. Furthermore, the variation in trace elements in chalcopyrite is influenced by fractional crystallisation of sulfide liquid in Ni-Cu sulfide deposits. The PLS-DA results show that, in VMS deposits, trace elements in chalcopyrite vary in function of VMS setting, which is determined by the host rock composition. Also, this study demonstrated that Random Forest is better than PLS-DA, KNN, ANN and NB methods for classification.

Although the trace element composition of chalcopyrite shows important variability within a deposit type, the results reveal that the chalcopyrite records a characteristic signature in its chemical composition according to the ore forming environment and highlights a strong potential to discriminate the source of mineralisation, as demonstrated by the RF models. This study demonstrates that chalcopyrite could be used as an indicator mineral and provides an opportunity to apply these methods in overburden sediments for mineral exploration.

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ID de réunion : 631 9424 2976

Code secret : 211197

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