Machine learning-assisted pyrite indicator mineral approach in mineral exploration

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Discovering new ore deposits that supply and satisfy the growing industrial demand for green transition metals is becoming more important than ever for transitioning into a non-fossil fuel future. This task however, appears to be unprecedented, when considering the required amount of technology metals. It becomes therefore highly relevant to develop and implement innovative and sustainable, but time- and cost-efficient exploration methods for deeply buried, undiscovered mineral deposits. A way to tackle this challenge is by using known European mineral deposits as testing grounds for new exploration technologies. For this purpose, the domestic mineral resources in northern Finland provide an ideal ecosystem and diversity of profitable green transition metals such as nickel, copper, cobalt and gold. The glaciated terranes in which these mineral systems occur, however, require special exploration methods such as the indicator mineral approach. Indicator minerals (e.g. sulfides, oxides and native gold) are recovered from glacial sedimentary samples and their individual grains are used for trace element analysis by LA-ICP-MS, which ideally could provide key information on the character of their source bedrocks, type of mineralization, as well as the glacial transport direction.

In this study we have tested the indicator mineral approach in the Rompas-Rajapalot Au-Co project areas in the Paleoproterozoic Peräpohja belt in northern Finland, by analyzing and comparing the trace element geochemistry of pyrite grains from bedrock and till samples. A machine learning-based approach was implemented using unsupervised self-organizing maps (SOM) and k-means clustering for mineralization-related pattern recognition. The obtained results show that pyrite grains recovered from till can be discriminated and clustered based on their compositions, and further correlated with pyrite from two hydrothermal deposit types within the study area: (i) the Au-Co mineral system at Rajapalot, and (ii) the vein-style Au system at Rompas. Mapping of recognized patterns, in accordance with ice flow directions, assists in (i) the localization of potential target-areas, (ii) and improves our understanding of similar mineral systems.