

Integrating Till and Bedrock Geochemistry Using Machine Learning for Gold Targeting in the Western Karelia Tectonic Province, Finland

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Regional geochemical datasets, particularly till and bedrock geochemistry, are important tools for mineral exploration in glaciated terrains such as Finland. In the Western Karelia tectonic province which host several well-known gold deposits like Kittila and Pampalo Mines is characterized by complex Paleoproterozoic geology, identifying prospective targets for mineral deposits remains challenging due to extensive glacial cover and geological heterogeneity.

This study aims to evaluate and compare the performance of machine learning approaches on till and bedrock geochemistry data. The dataset consists of multi-element analyses of till samples and complemented by geological descriptions and geochemical data from bedrock. A Self-Organizing Map (SOM) and Random Forest (RF) was applied to identify geochemical clustering patterns and to incorporate geological context and also improve predictive performance within these datasets.

The SOM analysis identified three geochemical clusters associated with known gold deposits and regional metallogenic belts. These clusters are characterized by elevated concentrations of pathfinder elements such as Ni, Co, Cu, and Cr, suggesting potential links to mineralized systems. However, the SOM-based model shows limited predictive accuracy when validated against known gold occurrences.

To address this limitation, the integration of geological variables through RF significantly improves model performance, achieving an accuracy approximately 40% higher than the baseline SOM model both for till and bedrock geochemistry data. Additionally, the model highlights key lithological and geochemical features that are strongly associated with gold mineralization.

These results demonstrate that integrating till and bedrock geochemistry with machine learning techniques, supported by geological domain knowledge, provides a robust framework for enhancing regional-scale gold prospectivity mapping in complex and covered terrains.