

Portable XRF for mineral exploration geochemistry in till

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Research to find new applications for regional and target-scale till geochemical exploration has been active for several years in Finland. Mineral potential mapping and exploration are active in those areas due to favourable bedrock in Fennoscandia. However, due to thick glaciogenic overburden, peat-cover and large conservation areas, geological and geochemical research and sampling are challenging. To find new solutions for surficial exploration in the sensitive Arctic and Subarctic regions advanced field analysing techniques have been tested. Aims have been to diminish the environmental impact and increase the cost-efficiency in mineral exploration. New tested methods include portable X-Ray Fluorescence (pXRF) analysers (Fig.1) supported by the laboratory XRF measurements and traditional partial leach geochemistry.



Fig. 1. Different pXRF methods tested as a part of till geochemical exploration in Finland. a) ScanMobile® XRF unit, b) till samples stored for the ScanMobile measurement, c) X-MET 3000TXR, and d) Delta 6000 analysers. Photos a, b, d by P. Sarala and c J. Valkama.

Introduction

One of the key methods in mineral exploration in glaciated terrains are surficial geological research and till geochemistry that have been used as practical exploration tools for nearly one hundred years. Glacial till has almost a total cover in large areas in Northern hemisphere which means that bedrock outcrops are rare. However, the till as a sampling media is very useful due to its glaciogenic nature and being a mixture of fresh bedrock, pre-glacial weathered bedrock and older sediments. Lithological and geochemical characteristics of the glacially dispersed till are an effective way to estimate transport distances and deposition processes of mineralised material in glaciogenic formations.

For the last few years the Geological Survey of Finland (GTK) have been applying modern pXRF analysers on a range of projects in Finland. A focus has been mainly in base metals (Cr, Cu, Ni, Zn) and gold but recently also in so called critical minerals and metals (like REEs, Lithium, PGE, Phosphor, Scandium) that have been considered highly important in EU's mineral strategy. Finland and whole Scandinavia have a key role in looking for new resources due to the mineral potential bedrock.

Development of the modern pXRF analysers has been effective during the last decade. The detection limits of these analysers are now low enough (ppm scale) for a large group of elements to make them very effective for regional exploration work. Portable equipment is light-weight and easy to take in the field. Several exploration examples from northern Finland proved the methods suitable and effective for exploration purposes in glaciated terrains.

Sinoselkä, central Lapland

Sinoselkä area is located in the central part of the main gold exploration and mine district in Kittilä, central Lapland. 623 till samples were taken by percussion drilling using lines with 50 m interval and distance about 100 m between the lines (18 lines with length ranging 1.0-3.0 km; Fig. 2). In this study Olympus Delta 6000 and X-MET 3000TXR hand-held analysers, and truck-mounted ScanMobile® XRF unit were used and compared together with the conventional aqua regia based till geochemistry (<0.06 mm size fraction).

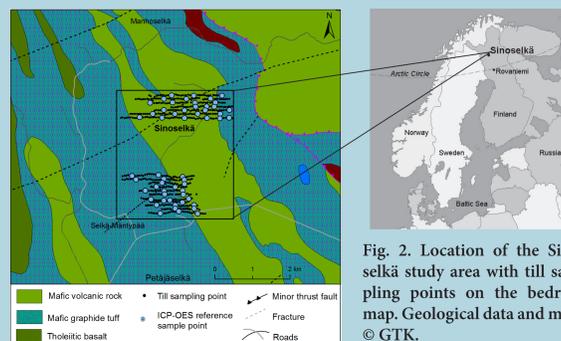


Fig. 2. Location of the Sinoselkä study area with till sampling points on the bedrock map. Geological data and maps © GTK.

The results prove that a correlation between different pXRF methods varied from excellent to moderate for the most of base and main elements. One of the main observations was also that although the absolute contents or levels of the elements can vary a lot, the relative values and their changes are those that should be considered and carefully examined (Fig. 3).

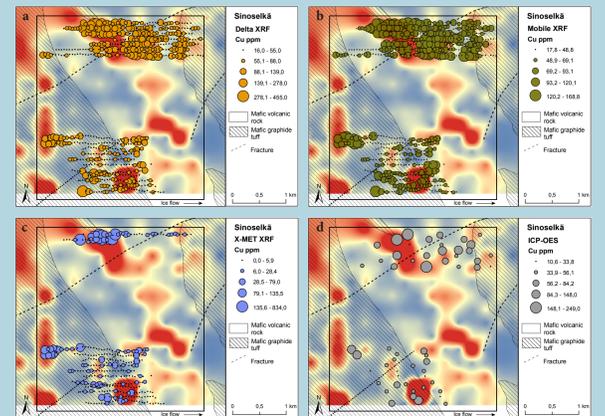


Fig. 3. Distribution of the Cu in till in Sinoselkä analysed by a) Delta 6000 pXRF, b) ScanMobile® XRF unit, c) X-MET 3000TXR pXRF and d) conventional till geochemistry (< 0.06 mm; aqua regia digestion and ICP-OES). Distribution of Cu in 250-m-grid till geochemistry (<0.5 mm; milled before aqua regia; ICP-OES) is shown in the background.

Savukoski-Pelkosenniemi, eastern Lapland

In another example, the till samples were collected from the test pits and soil drilling cores as a part of Project 'Novel technologies for Greenfield exploration' (funded by Tekes) in the Savukoski-Pelkosenniemi area (Sarala et al. in press). In this case, three different sample types: a) natural, moisture, unprocessed, b) natural, dry, unprocessed and c) pulverized, pressed till samples (< 2 mm fraction) analysed by pXRF were compared with the laboratory XRF and aqua regia based till geochemical results (Fig. 4).

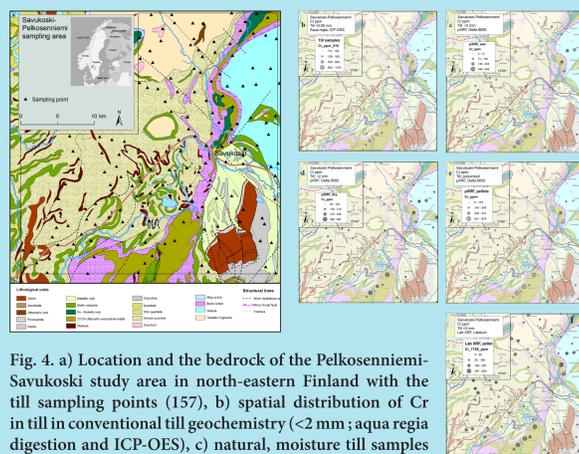


Fig. 4. a) Location and the bedrock of the Pelkosenniemi-Savukoski study area in north-eastern Finland with the till sampling points (157), b) spatial distribution of Cr in till in conventional till geochemistry (<2 mm; aqua regia digestion and ICP-OES), c) natural, moisture till samples by Delta 6000 pXRF and, d) natural, dry till samples by Delta 6000 pXRF, e) till pellets (pulverised and briquetted) by laboratory XRF and f) till pellets by Delta 6000 pXRF. Geological data and maps © GTK.

Conclusions

The use of pXRF provides a cost-effective field analysis method in exploration by decreasing analytical costs, increasing sample efficiency and giving a possibility to the real-time till geochemistry, and by this way support environmentally-friendly exploration. The great benefit is that even natural, moisture, unprocessed till samples can be used, and results are comparable with the conventional till geochemistry. Real-time analytics provide quick directing of the till geochemical sampling and focusing into most potential exploration targets within the study area.

Based on the practical experience using Olympus Delta 6000 pXRF, correlations between the pXRF analyser, laboratory XRF and even ICP-AES (based on aqua regia leaching) analyses are mostly excellent or good or for the large group of elements (Fig. 5). Even natural, wet, unprocessed samples can be used but dried, sieved samples or pulverised and compressed pellets increase accuracy. In this case, it was also seen that the pXRF results are excellent and highly accurate to the base metals giving possibility for the absolute value measurements, but relative values and trends are mostly worth considering.

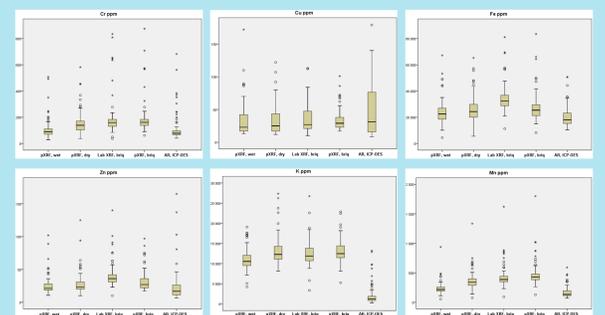


Fig. 5. Comparison of the distribution of different sample/analyser datasets for Cr, Cu, Fe, Zn, K and Mn. (pXRF, wet = natural, moisture till samples analysed by Delta 6000 pXRF; pXRF, dry = natural, dry till samples analysed by Delta 6000 pXRF; Lab XRF, briq = till pellets (pulverised and briquetted) analyzed by laboratory XRF; pXRF briq = till pellets analysed by Delta pXRF; AR, ICP-OES = <2 mm till size fraction analysed analysed after pulverising and aqua regia digestion by ICP-OES).

References:

- Sarala, P. Comparison of different XRF methods in exploration using till. *Geochemistry: Exploration, Environment, Analysis*. Submitted manuscript.
- Sarala, P., Taivalkoski, A. & Valkama, J. Portable XRF – Advanced on-site analysis method in till geochemical exploration. *Geological Survey of Finland, Special Paper*. Accepted manuscript.

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