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PROGRESS REPORT ON SAMPLING METHODS FOR IDENTIFYING GEOCHEMICAL HALOS

BATCircle2.0 Project

WP1 (Battery Minerals Exploration and Responsible Mining)

Task 1.2 (Advanced Exploration Techniques)

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Title of report Progress Report on Sampling Methods for Identifying Geochemical Halos			
Abstract The Geological Survey of Finland (GTK) carried out geochemical sampling in the municipality of Kaustinen in order to identify geochemical halos occurring around the so-called LCT pegmatites. The sampling methods used during the 2022 field season were the weak leach technique for upper soil geochemistry, bark sampling and snow sampling. The sampling took place along seven sampling lines in the field with a total length of 15 750 m. This work formed part of Task 1.2 (Advanced Exploration Techniques) of Work Package 1 (Battery Minerals Exploration and Responsible Mining) of the BATCircle2.0 project (2021–2024), funded by Business Finland.			
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1 PROGRESS REPORT ON SAMPLING METHODS FOR IDENTIFYING GEOCHEMICAL HALOS

The weak leach technique for upper soil geochemistry, bark sampling and snow sampling were the sampling methods for identifying geochemical halos that were applied and tested in the BATCircle2.0 Project during the 2022 field season.

The length of sampling lines in the field was 6 225 m for weak leach samples, 7 425 m for bark samples and 2 100 m for snow samples, totalling 15 750 m. Snow sampling and the first round of bark sampling took place between 14 and 16 March 2022. Soil sampling for weak leaching and the second round of bark sampling took place between 31 May and 9 June 2022.

Percussion drilling and excavator sampling are widely used till sampling techniques that will be tested during the 2023 field season. This will include trench and test pit sampling for geochemical studies and heavy mineral studies (Sarala 2015).

The research area is located in Kaustinen, Central Ostrobothnia, on the eastern outskirts of the Leviäkangas lithium-pegmatite deposit.

1.1 Geochemical exploration of LCT pegmatites

LCT pegmatites (lithium-caesium-tantalum) have a certain type of geochemical signature. Volatiles that migrate from the crystallized pegmatite into the adjacent lithologies typically form a halo in which these same chemical elements are enriched (Kurtti 2018). Glacial processes and movements of groundwater have caused further dispersion of these chemical elements into the overlying till cover.

The bedrock in Finland and other Nordic countries is mostly covered by sediments. The average thickness of glacial sediments in the study area is approximately 6 metres. Therefore, it is challenging to find any direct reference to LCT pegmatites such as lithium critical rock units in bedrock. However, geochemical sampling from glacial boulders, till, water, plants, mineral fractions and other sample media can be used to identify lithium and other “pathfinder” elements.

Another challenge is brought about by the dispersion of anomalous concentrations of chemical elements by relatively recent geological processes. Compared to any lithium occurrence and surrounding halos in bedrock, in till, these geochemical signals occur in concentrations that are at least 1 000-fold weaker. This is because when bedrock erodes into sediment, the volume of loose rock material becomes much larger. Trace amounts of chemical elements appear even more diluted after having been transported over distances from the original lithium deposit. In addition, local variations in the stratigraphy of the till cover and fluvial events make the work even more complicated.

Compared to diamond drilling, geochemical methods, such as water and till sampling, are rapid and inexpensive for detecting the weak signals of chemical elements indicative of LCT pegmatites (Li, Be, Ta, Nb, Rb, K, Cs and Sn). The same benefits apply to heavy mineral studies on indicator minerals such as spodumene, biotite, muscovite, chlorite and tourmaline. This type of geochemical sampling is usually performed at large numbers of sampling points that are arranged in the form of a grid or along lines that cover large areas of critical geology or regions of high exploration potential. The geochemical sampling described in this report was conducted along seven sampling lines crossing previously known fans of glacial boulders.

2 WEAK LEACH METHOD

The weak leach method is based on the analysis of mobile chemical elements that have risen from the bedrock together with groundwater up to the level of the topsoil. The technique is relatively widely used for detecting so-called blind mineralization (mineralization not extending to the surface of the bedrock). The sampling is also environmentally friendly, because it can be carried out by walking to the sampling locations and only light digging tools are used. The method utilizes chemical elements that are weakly attached to soil particles and can be leached with dilute reagents (Smee 1999, Sarala et al. 2016).

2.1 Analytical technique

The analytical technique used for weak leach samples (topsoil) in this project was ALS method ME-MS23 ionic leach. It is a so-called static sodium cyanide leach using the chelating agents ammonium chloride, citric acid and EDTA with the leachant buffered at an alkaline pH of 8.5. Concentrations and the detection limit are in parts per billion (ppb). Analyses were performed using inductively coupled plasma mass spectrometry (ICP-MS).

2.2 Sampling

Up to 138 soil samples (duplicates included) were taken at 50-m intervals along six sampling lines (L2−L7). The minimum weight of each sample was 200 g, and they were taken using a plastic garden spade (from the podzolic B or C horizons, Fig. 1). The sample pits were dug by using an unpainted shovel, and the depth of the pits was approximately 20 cm. The sampling points were located by GPS. pH measurements were only taken during the first sampling week (due to equipment failure in the second week). The total length of the SW–NE-directed sampling lines was 6 225 m. The samples were collected by two pairs of field workers.

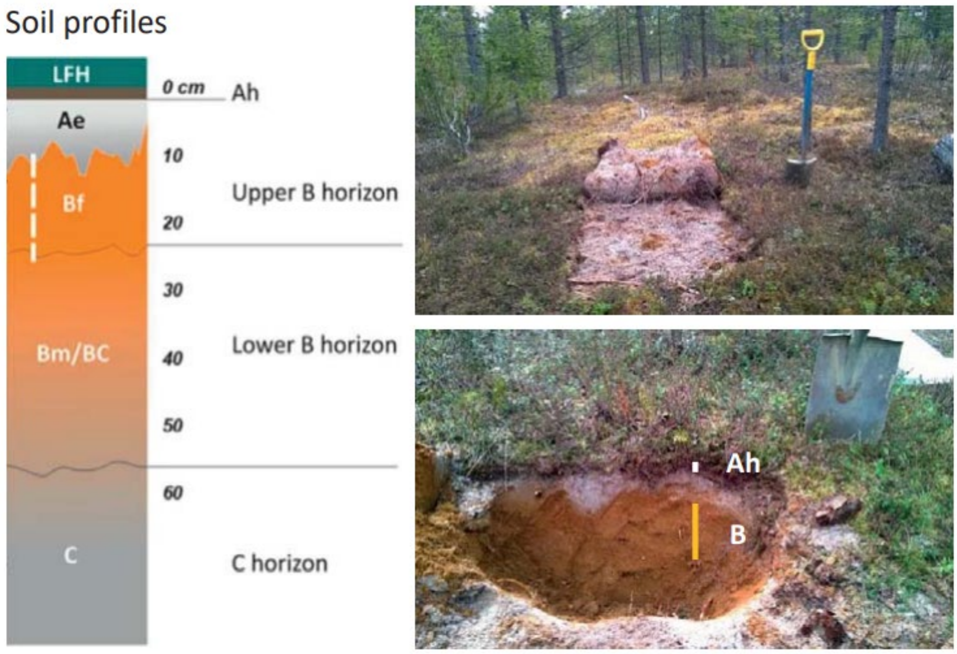

Fig. 1. Typical sampling layers for upper soil geochemistry (Ah horizon and upper part of the B horizon). The figure is from Sarala (2022).

3 BARK SAMPLING

Plants obtain nutrients from groundwater, and some chemical elements are enriched in certain types of vegetation and in specific parts of the plant. One of the most potential methods utilizing vegetation in targeting locations critical for metallic ores is pine bark chemistry (Hawkes 1957, Kovalevskiy 1978, Kettunen 2022, Middleton et al. 2020). The method was recently tested on lithium potential areas in Kaustinen during the Green Minerals Project (2018−2020). Some indicative concentrations were detected, and the method has been further tested and developed in the BATCircle2.0 Project. Geochemical signals in organic media can also be explored by sampling other plants. However, birch leaves, for example, can only be collected in summer, while bark samples can be collected during any season, including winter (Fig. 2).

Fig. 2. Pine bark sampling in the Kaustinen study area with a metallic scraper in winter (mid-March 2022). Photo: S. Leinonen.

3.1 Analytical technique

Bark samples were delivered to the laboratory of Actlabs. The analytical technique used was inductively coupled plasma mass spectrometry (ICP-MS). Sample preparation consists of drying and maceration of the vegetation in a Retsch cutting mill with an internal 1-mm sieve (code B2). Raw vegetation samples are digested in aqua regia at 95 °C for two hours, and the resultant sample solutions are diluted and analysed. Results are presented in parts per billion (ppb).

3.2 Sampling

Bark samples were taken at 25-m intervals along five SW–NE-trending lines and along two lines 50-m intervals with a total length of 7 425 m. During the Green Minerals Project, weak leach samples had been already taken along one of the lines (L1) in 2018 at 50-m intervals, i.e., partly overlapping the present bark sampling sites. The sampling practice was to collect a bark sample from each tree at a height of 1.5 m by using a metallic scraper and a plastic scoop. The minimum mass of the sample taken at each location was 50 g (recommended to be taken from all sides of the tree trunk). Each sample was weighed and then placed in a fabric sample bag. The bark and the bag were dried before storage and subsequent delivery for analysis. The diameter of pine tree trunks was on average 17 cm. About 10% of the sampled pine trees were older ones with a trunk diameter exceeding 25 cm, while about 10% were young trees with a diameter of 6−10 cm. The bark sampling was carried out by one pair of field workers in about a week. Altogether, 277 samples, including 22 duplicates, were collected.

4 SNOW SAMPLING

The geochemistry of snow is one of the applications of the Mobile Metal Ion (MMI) analysis technique used to detect geochemical anomalies. The idea behind the method is that snow collects chemical elements moving upwards in gaseous form from bedrock sources. Late winter (early spring) is the most optimal time for sampling, because a thick snow layer better traps geochemical signals and prevents contamination from air sources (e.g., pollutants).

There has been interest in snow geochemistry in ore prospecting because of its usability in environmentally sensitive areas in the northern peripheries of Scandinavia (Sarala 2015, Taivalkoski et al. 2016, Sobolev et al. 2022). Analytical techniques applicable for snow samples include the spatiotemporal geochemical hydrocarbon (SGH) method or high-resolution inductively coupled plasma mass spectrometry (HR-ICP-MS) (Taivalkoski et al. 2019).

4.1 Analytical technique

Sample preparation in the laboratory involves the melting of the snow and filtering of 10 mL of the resulting water for analysis. To ensure quality control, 10-fold-diluted multi-elemental calibration solutions were analysed together with the samples at the beginning of each run and at the end of each run of 24 samples. In addition, the international river water SLRS-5 standard (20-fold diluted) was measured several times during the runs. A 90-second wash was included between measuring each sample. The instrumentation used for snow analyses was an SC-ICPMS (Nu Instruments Ltd., Wrexham, UK). Analyses were performed by Minna Myllyperkiö and Yann Lahaye at GTK Espoo Research Laboratory.

4.2 Sampling

Snow samples were carefully taken to avoid any contamination. Snow samples can be easily collected by pushing, for example, an acrylic tube horizontally against the snow and transferring the trapped snow directly into an acid-treated ultra-pure plastic jar (Fig. 3). The recommended sampling depth is 10−20 cm from the bottom of a snow pile. Samples are kept frozen until analysed. In March 2022, snow sampling was conducted along two SW–NE-trending lines at 50-m intervals, totalling 49 samples (4 duplicates included) and 2 100 sampling line metres. The sampling is usually easy to carry out by one pair of field workers. During the three-day field session in March 2022, five persons were occupied in the research area.

Fig. 3. A snow sample being taken into an acrylic tube. Kaustinen, March 2022. Photo: S. Leinonen.

5 SUMMARY

During the 2022 field season, upper soil samples for the weak leach method, pine bark samples and snow samples were taken along seven sampling lines in the field with a total length of 15 750 meters. All 473 samples (9 references included) have been delivered to analytical laboratories. These comprise 140 upper soil samples (with 2 references), 284 pine bark samples (7 references) and 49 snow samples (laboratory's own references used).

Percussion drilling and excavator sampling are widely used till sampling techniques that will be tested in the 2023 field season. The samples will be used for both chemical analyses and heavy mineral studies.

All sampling methods mentioned and the results from the analyses will be presented in the BATCircle2.0 deliverable "Final report on sampling methods for identifying geochemical halos", due in April 2024.

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