Application of geochemical micro-analytical methods in tracing Nickel through the battery value chain: a case study from Finland

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Nickel (Ni) is an essential raw material widely used in the cathodes of rechargeable batteries. As the electric vehicles market grows fast, the global demand for Ni in lithium-ion batteries production is also rapidly increasing. The global Ni value chains are complex due to the unevenly distributed primary mining sources, multiple refining processes and their manufacturing demand. The ability to identify the Ni sources and fingerprint Ni along its value chain is critical yet challenging. Magmatic sulfide deposits are one of the important sources for Ni, are abundantly distributed in Finland. Finland also offers a complete value chain from mining and refining to the recycling of batteries. In this study, we collected the ore deposits samples from Kevitsa Mine in the north Finland, which is regarded as one of the largest Ni reserves in Finland. Mineral concentrate and processed samples with a large variety of properties along the multi-stages of battery value chain with known source of Kevitsa are also obtained. We first used a µ-XRF for quick elemental mapping and sulfide mineral identification for the core and mineral concentrate samples. Then it is followed by using a scanning electron microscope (SEM) to acquire high-resolution mineral feature analysis and mineral composition quantification. Sulfur bearing mineral grains, e.g., chalcopyrite, pyrite, pyrrhotite, pentlandite and cobaltite were imaged and positioned by SEM for further trace element and sulfur isotope in-situ analysis with LA-ICP-MS. For processed samples along the value chain, such as residue and solution after leaching, iron removal samples and the $NiSO_4$ powder, they were prepared as pressed pellets and their bulk trace elements and sulfur isotope compositions were obtained by in-situ LA-ICP-MS. Finally, the trace element compositions and sulfur isotope ratio of these samples are compared by multivariate data analysis to extract the robust fingerprint that possibly remained along the value chain. The effect of extractive and refining metallurgy in altering geochemical signature of the original ore deposits would also be evaluated. The above laboratory analyses are all implemented at the Espoo Research Laboratory of Geological Survey of Finland. By a combined application of the multi micro-geochemical analytical techniques, we aim to develop a geochemical fingerprinting tool to trace Ni from the original mining ores to the end products. The outcome of this research would help to reinforce the transparency, reliability and sustainability of the raw materials supply along the complex battery value chain.