More than meets the eye: investigating critical elements in sulfides from different ore deposit types

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Mineral geochemistry has multiple applications for understanding the geological processes that formed the mineral. Plenty of research has been done on trace element compositions of sulfides from different ore deposit types to find a deposit-type characteristic geochemistry. Besides the characterization applications of trace element analyses, it is also important to investigate the presence and distribution of 'critical elements' in ore deposits. Critical elements are elements that have a growing economic importance and high supply risk. The European Commission publishes a list of critical elements, including Co, Ga, Ge, In, Sb, Bi and platinum group elements, which commonly occur in sulfide minerals in varying concentrations. Many of these elements are used in green technology and new sources of these elements are required to fulfill our goals of a sustainable green future. Most of these critical elements rarely form distinct minerals but are rather hosted in trace to minor amounts within other minerals and are thus commonly mined as by-products from other targeted resources. We apply an array of geochemical methods to study the distribution of critical elements in sulfides, with a major focus on LA-ICP-MS trace element analyses. Laser ablation (LA)-ICP-MS enables in situ analyses of small (30–100 µm) and precise parts of the sulfide minerals. As most ore deposits form through multiple phases of mineralization, sulfides commonly show zonation and generational differences in geochemistry. Trace element mapping by LA-ICP-MS and EMPA are both powerful tools for element distribution visualization. Our research indicates that many different ore deposit types show potential for being sources for critical elements, as by-products from mining other base metals. Sphalerite from European Alpine-type carbonate-hosted Pb-Zn and many MVT deposits contains significant concentrations of Ga and/or Ge. The sphalerite from these carbonate-hosted deposits commonly occurs with banded textures, indicating multiple generations, and LA-ICP-MS data shows a wide variation in trace element concentrations. The Polish Kupferschiefer hosts djurleite with elevated Re concentrations and chalcopyrite from later stages of mineralization with higher concentrations of Ga. The Dolostone Ore Formation mineralization in Namibia, a sediment-hosted Cu-Co mineralization, does not only contain Co-sulfides but both pyrite and sphalerite contain high concentrations of Co. Although pyrite contains abundant Co-bearing micro-inclusions, sphalerite seems to host lattice-bound Co. Evident from all these studies is that sulfide trace element composition varies between the different generations of ore formation at these different deposits. This is an important aspect to keep in mind when exploring for critical elements and designing metallurgical test work programs. In addition, we are also looking into the evaluation of old mine tailings as a possible source of critical elements as these elements used to have no value and were therefore disregarded during processing. Being able to re-process old mine tailings could provide a sustainable source of critical elements.