Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.22965

Controls on germanium (Ge) enrichment in sediment-hosted zinc-lead deposits

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Germanium (Ge) is a crucial mineral in advancing technology, especially in solar energy. It is commonly recovered as a by-product of zinc (Zn), which poses potential future supply risks, defining it as a critical mineral. Globally, Ge is commonly sourced from sediment-hosted Zn-Pb deposits. However, the mineralogy, deposit-scale distribution, and enrichment mechanisms associated with Ge within these deposits remain poorly understood. Consequently, we examine the Ge-bearing Zn-Pb (Ag) Prairie Creek sediment-hosted deposit located in the Northwest Territories, Canada, using macro- to nano-scale analyses. We aim to refine the genetic model of this deposit and identify key factors influencing Ge accumulation.

This deposit exhibits two main mineralization styles: 1) stratiform and 2) quartz-carbonate vein, hosted mainly in Ordovician to Silurian sedimentary rocks. Using whole-rock geochemical analysis with orthophosphoric acid digestion, we determined that only the stratiform style of mineralization contains potentially economic values of Ge (up to 300 ppm). The results show a strong correlation between Ge and Zn, indicating that Ge content is associated with Zn-bearing mineral phases. At least two generations of sphalerite (ZnS; Sp I and Sp II) are present in the stratiform mineralization. Analysis of sphalerite chemistry using EMPA reveals significant Ge enrichment (up to 2600 ppm) exclusively in Sp I. In contrast, Sp II has Ge concentrations below the detection limit (170ppm). Furthermore, trace element maps show a spatial correlation between Cu and Ge within sphalerite crystals and concentrations determined by spot analysis reveal a 2:1 ratio. This suggests a possible relationship between these two elements in their substitution mechanisms.

We will use LA-ICP-MS to collect additional trace element concentration data in sphalerite and other sulfides. Additionally, we will employ analytical techniques such as EBSD and APT to characterize the crystallographic and atomic distribution of Ge in sphalerite. These analyses, along with isotopic studies, are planned to investigate the sources of metals and sulfur, the nature of ore-forming fluids, and conditions for metals precipitation and preservation. This work will contribute to a better comprehension of Ge behavior in hydrothermal fluids in sedimentary environments, guiding mineral exploration and mining strategies targeting these deposits.