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Controls on Germanium Enrichment in Zn-Pb Sediment-Hosted Mineral Deposits

Juan D. Bello Rodriguez¹, Daniel Gregory¹, Merilie A. Reynolds², Denis Fougere³

1. University of Toronto, Toronto, ON, Canada, 2. Northwest Territories Geological Survey, Yellowknife, NW, Canada, 3. Geoscience Atom Probe Facility, Curtin University, Perth, WA, Australia

Germanium (Ge) 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 frequently sourced from sediment-hosted Zn-Pb deposits. However deposit-scale distribution and enrichment mechanisms 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 enrichment.

This deposit exhibits two main mineralization styles: (1) stratiform and (2) quartz-carbonate vein, hosted mainly in dolostone and shales. Using whole-rock geochemical analysis, we determined that only the stratiform style contains 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 and LA-ICP-MS reveals significant Ge enrichment (up to 2,600 ppm) exclusively in Sp I. In contrast, Sp II has lower Ge concentrations (0.5 to 100 ppm). Furthermore, EMPA elemental maps show a spatial correlation between Cu and Ge within sphalerite crystals (2:1 ratio). This suggests a possible relationship between these two elements in their substitution mechanisms.

We will use electron backscatter diffraction (EBSD) and atom probe tomography (APT) to characterize the crystallographic and atomic distribution of Ge in sphalerite. In addition to isotopic analyses, this work will give insight into the sources of metals and sulfur, the nature of ore-forming fluids, and conditions for metal precipitation. This research will contribute to a better comprehension of Ge behavior in hydrothermal fluids in sediment-hosted Zn-Pb deposits, guiding mineral exploration and mining strategies targeting these deposits.