Constraining potential metal zonation trends and origin of the enigmatic Ag-Ni-Co-As-Bi mineralization of Cobalt, Ontario

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Summary

The recent emergence of Co as a critical metal used in a variety of high-technology industries (e.g., high-quality batteries) has focused exploration on the enigmatic five-element (Ag-Ni-Co-As-Bi) deposit type, including the vein systems at Cobalt, Ontario. This area was Canada's premiere Ag producing district where over 460 Moz of Ag was extracted (1904-1989). Currently, there is a limited understanding of what geological variables controlled metal distribution and localization across this area, which is essential for future exploration success. Here regional metal zonation trends are presented which were developed from integrated field mapping, whole rock analysis, and petrological (ore petrography, SEM-EDS) investigations of five-element ore samples, which is constrained by a reassessment of the complex mineral paragenesis. Mineralized vein samples (>500) from rock piles adjacent the past-producing mine sites across the historical Cobalt mining district (1,250 km^2) were collected and analyzed for a spectrum of metals (Co, Ni, Ag, As, Bi, Au, Cu, Pb, Zn, Mo, Sb, Hg) at a commercial laboratory. The data were subdivided into percentiles ($<P_{75}$, P_{76-90}, P_{91-95}, P_{96-99}, $>P_{99}$), as well as major mineral groupings, to identify high-metal anomalies. The data was plotted spatially to assess regional metal trends and potential association with major structures and proximity to different lithologies. Results indicate a strong covariance among Co-Ni-As-Bi-Sb but variable Ag distribution. No district-scale metal zonation is observed. At the micro-scale, mineralized samples reveal a general paragenesis of early native Ag, through arsenide to sulfarsenide (from Ni to Co to Fe solid-solution), and to later overprinting base-metal sulfides. This paragenesis is further refined by noting that coupled dissolution-precipitation (CDP) textures record replacement of arsenides by multiple generations of arsenide and sulfarsenide phases. Locally cross-cutting relationships also indicate clear evidence for late remobilization of native metals. The apparent lack of metal zone refinement of this mineralization is preliminarily interpreted to reflect a potential lack of district-scale fluid-chemical or thermal gradient control on mineralization. Additionally, the superimposition of different fluids invoking changing chemical parameters (i.e., pH, fO_2) created different evolutionary paths on a local scale within the vein network. This inferred geochemical evolution of the mineralization will be used to assess the cause of the regional metal enrichment and implications for future exploration in the Cobalt region. CFREF-Metal Earth Project Contribution MERC-ME-2020-044.