

Mineralogical and geochemical evidence for syngenetic precious metal enrichment in a deformed volcanogenic massive sulfide (VMS) system

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Introduction

The early Ordovician Ming Mine (487 Ma; total resource 12.5 Mt ore @ 1.52 wt% Cu, 1.69 ppm Au, 8.11 ppm Ag, and 0.45 wt% Zn), NW Newfoundland, Canada, is a type example of a precious metal-enriched VMS deposit. Moderate deformation and metamorphism makes deciphering the origin of Au-Ag-enrichment (e.g., syngenetic vs. epigenetic) difficult. However, mineralogical and geochemical evidence support a syngenetic origin with Au-Ag coming via a magmatic contribution to the primary VMS hydrothermal fluid [1, 2, 3]. Mineralogical observations show a complex sulfide mineral assemblage in stringer and massive sulfide mineralization. Besides base metal sulfides (e.g., pyrite, chalcopyrite, sphalerite, galena, pyrrhotite), sulfosalts rich in magmatic suite elements (e.g., arsenopyrite, tetrahedrite-tennantite, stannite, boulangerite, loellingite), Te-bearing phases (e.g., BiTe, coloradoite), Ag-phases (e.g., miargyrite, unnamed AgCuFeS phase, argentotetrahedrite, AgHg alloy), and electrum occur throughout the deposit, but are slightly more enriched in the upper part of the deposit. Main, minor and trace element analysis by electron microprobe (EPMA) show the enrichment of magmatic suite elements (e.g., As, Bi, Hg, Sb, Sn, Te) as major, minor and trace constituent in base metal and other sulfides phases.

Results and Conclusions

Electrum and Ag-phases occur as: (1) free phases in gangue or on pyrite/chalcopyrite margins; (2) as inclusions in pyrite, arsenopyrite, pyrrhotite, and galena; (3) along veinlets in and on grain boundaries of pyrite and arsenopyrite; (4) in odd myrmekitic-like textures; and (5) in close proximity to each other and tetrahedrite-tennantite. EPMA data on 17 elements in sulfide and precious metal phases reveal: (1) no invisible gold in any phase; (2) a high Hg-content (12 – 17 wt%) in electrum; and (3) sphalerite with a varying Fe-content (2 – 9 wt%). The mineralogical and geochemical features of the ores favor a syngenetic, magmatic origin for precious metal enrichment. However, later deformation remobilized some metals, especially Au and Ag, as evidenced by textural relationships and the absence of invisible gold.

[1] Sillitoe et al. (1996) *Economic Geology* **91**, 204-212. [2] Hannington et al. (1999) *Reviews in Economic Geology* **8**, 325-351. [3] Huston (2000) *Reviews in Economic Geology* **13**, 401-426.

From aqueous to solid solutions: A process understanding of trace metal incorporation into solid structures

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Introduction

Aqueous-solid solution systems are ubiquitous in natural and anthropogenic systems and they influence the fate and mobility of heavy metals and radionuclides.

The process understanding of the structural incorporation of trace components into existing or forming solid phases is essential to the assessment of the potential environmental consequences.

Objective of the presentation

In my presentation I will introduce some of the key concepts involved in the suite of processes that are involved in the transition of a trace component from the aqueous to the solid solution both from the kinetic and thermodynamic points of view.

I will devote particular attention to recent solution chemical and spectroscopic data that has been recently acquired in the frame of the EC Funmig project[1] and I will frame it to the conceptual developments presented in [2]

I will also propose some ways forward to integrate the experimental information on the structural incorporation of trace elements into the current models used in current environmental assessments.

[1] Bruno, J. and Montoya, V. (2012) *Applied Geochemistry*, **27**, 444–452

[2] Bruno, J., Bosbach, D., Kulik, D. Navrotsky, A., (2007) *Chemical Thermodynamics of Solid Solutions of Interest in Nuclear Waste Management Chemical Thermodynamics Volume 10. OCDE-NEA*.