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Dissolution-reprecipitation vs. solid-state diffusion in electrum: Examples from metamorphosed Au-bearing, volcanogenic massive sulfide (VMS) deposits

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Abstract

Native Au-Ag alloys (electrum) are the predominant precious metal host in Au-bearing volcanogenic massive sulfide (VMS) deposits. The chemical composition and distribution of electrum records crystal growth and post-crystallization processes. In this study, we present detailed textural and compositional data of electrum from the Ming (Canada) and Boliden (Sweden) Au-bearing VMS deposits.

Electron probe micro-analyzer (EPMA) and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) analyses of electrum enable characterization of chemical zoning in heterogeneous electrum grains. Electrum from Ming exhibits Ag-rich cores, in gradational contact with an outer Au-rich transition zone also enriched in S, Fe, Cu, Zn, and Pb, which is in sharp contact with Ag-rich rims. The textural observations, coupled with in situ LA-ICP-MS data, highlight that the electrum zoning arises from a complex interaction between fluid facilitated solid-state diffusion (SSD) within the grain and coupled dissolution and reprecipitation (CDR) reactions at the grain interface, in response to changing fluid composition and extrinsic parameters, such as temperature, pH, and redox state at Ming. Electrum from Boliden, in contrast, shows an Au-rich core in contact with a gradually increasing Ag-rich rim enriched in Se, Bi, Sb, Te, Sn, S, and Zn, which indicates the formation by fluid facilitated SSD reactions. The different local re-equilibrium caused by SSD from two deposits are attributed to different transport ligands and effects of physicochemical parameters of fluids (e.g., pH and f_{O_2}), resulting in different compositional zoning patterns within the electrum. The long-lived metamorphic events that affected the occurrence and compositions of electrum at both VMS deposits, probably provided the elevated temperature and deformation to allow pervasive fluids to remobilize trace metals in electrum, which resulted in the complex chemical zoning in electrum. This study provides insights from in situ, textural and chemical analyses to understand the formation of complex chemical zoning in electrum in metamorphosed VMS deposits.

Keywords: Zoned electrum, dissolution and reprecipitation (CDR), solid-state diffusion (SSD), Ming, Boliden, Au-bearing VMS