Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.27044

Metamorphic remobilization of precious metals and critical metals as function of pyrite texture, composition and brittle-ductile behavior: Example from the epithermal Haile deposit, South Carolina, USA

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The Haile deposit, South Carolina, is a high-tonnage, low-grade, pyrite-dominated, Au-Ag, low-sulfidation epithermal deposit hosted in the Carolina terrane and formed during the Neoproterozoic. It underwent greenschist metamorphism during the Ordovician Taconic orogeny in which sulfides, precious and critical metals endured remobilization. The degree of physical and chemical remobilization is here characterized with focus on the role of trace element abundance within pyrite and its brittle-ductile behavior during remobilization.

Although remobilization of sulfides, precious and critical metals is a common occurrence in metamorphosed hydrothermal deposits, both the impact of remobilization deposit-wide and what process(es) facilitate the translocation of metals is debated. A combination of textural (microscopy) and compositional (electron probe micro-analyzer, laser ablation inductively coupled mass spectrometry, secondary ion mass spectrometry investigations were applied on pyrite to decipher their behavior during metamorphism and deformation.

Of the three pyrite types (Py1a, Py1b, Py2) identified, Py1a and Py1b were formed syn-genetically during the Neoproterozoic by dominantly reduced, mildly acidic to near neutral, magmatic-derived fluids at ≈ 290°C. Arsenic, precious metals and critical metals were incorporated into the pyrite structure syn-genetically (Neoproterozoic) with up to 2.49 wt% As. 103 ppm Au, 482 ppm Sb, and 145 ppm Te. Py2 was formed syn-D2 or post-D2 of the Ordovician Taconic orogeny as newly crystallized, coarse, subhedral to euhedral pyrite around porous anhedral Py1b by oxidized, mildly acidic to near neutral, metamorphic fluids. Trace element contents are overall at least a magnitude lower in Py2 compared to the older syn-genetic pyrite.

During the Taconic orogeny, all three pyrite types experienced crystal-plastic and brittle deformation, albeit to different degrees. This physical remobilization was accompanied by chemical remobilization which was driven by coupled dissolution reprecipitation reactions between porous Py1b and metamorphic fluids and resulted in the liberation of precious and critical metals. The liberation and transport of precious and critical metals was enhanced by pores and cataclastic cracks in Py1b.

Although remobilization is a local process and occurs at the micro-scale, it impacted all ore zones at Haile and played a major role in refining and upgrading the precious metal and critical metal tenor of the deposit.