Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36074

Mobilization and hyper-enrichment of gold mediated by dissolution-reprecipitation from gold deposits in the Baie Verte Peninsula of Newfoundland, Canada

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The formation of high-grade gold deposits is frequently associated with recurrent reactivation and enrichment driven by multi-stage geological processes, such as metamorphism and hydrothermal metasomatism. However, identifying the mechanisms of late-stage gold mobilization and hyper-enrichment remains challenging. Traditional research has predominantly focused on the in-situ structure and composition of gold-bearing host minerals, such as sulfides. However, there is a notable lack of studies targeting the ultra-microstructure and trace element geochemistry of the gold minerals themselves. This critical gap has limited our profound understanding of the mechanisms governing gold mobilization and hyperenrichment.

To address this gap, we present detailed textural and compositional data of gold, the predominant precious metal host in Au-rich volcanogenic massive sulfide (VMS) deposits, from the Ming deposit in Newfoundland, Canada. The Ming deposit is hosted in the upper part of the Rambler Rhyolite Formation, which is a folded, dome-shaped sequence of quartz-phyric rhyodacite, quartz-bearing intermediate to felsic tuff, and tuff breccia formed during the Cambrian-Ordovician. Upper greenschist to lower amphibolite facies metamorphism affected most of the Rambler Rhyolite Formation.

By integrating micromorphological characterization with quantitative trace element analysis, we conducted a rigorous mineralogical investigation of distinctly zoned gold grains. Using high-resolution transmission electron microscopy (HR-TEM/STEM), electron probe microanalysis (EPMA), and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), we correlated the nanoscale microstructure of gold with its trace-element geochemistry to elucidate the physicochemical constraints of metasomatic reactions at the ultramicroscopic scale.

Results reveal that gold from the Ming deposit exhibits Ag-rich cores in gradational contact with an outer Au-rich transition zone (also enriched in S, Fe, Cu, Zn, and Pb), which in turn shares a sharp contact with Ag-rich rims. These textural observations, coupled with in situ LA-ICP-MS data, indicate that gold zoning arises from complex interactions between fluid-facilitated solid-state diffusion (SSD) within the grain and coupled dissolution-reprecipitation (CDR) reactions at the grain interface. These processes occur in response to evolving fluid compositions and extrinsic parameters, such as temperature, pH, and redox state. Ultimately, this approach provides novel evidence for understanding the mechanisms of nanoscale gold mobilization and metamorphic enrichment in high-grade deposits.

