Application of fluid inclusions and mineral textures in exploration for epithermal precious metals deposits

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During the past two decades considerable advances have been made in our understanding of metal transport and deposition in Au-rich epithermal systems. Less work has been done to understand the genesis of Ag-rich deposits. The search for mineral deposits is a time consuming and risky process, and any technique that can help the explorationist to quickly and inexpensively discriminate between areas with high potential for economic mineralization and those with lower potential provides a competitive advantage to those applying the technology. Here we describe a method based on fluid inclusions and mineral textures that may be applied in exploration for Ag-rich epithermal deposits.

The Guanajuato mining district is one of the largest silver producing districts in the world. Ore shoots are localized along three major northwest trending vein systems, the La Luz, Veta Madre and Vetas de la Sierra. Mineralization in the district shows much variability between and within deposits, from precious metal-rich to more base-metal-rich zones, and from gold-rich to silver-rich zones. Ore textures also vary and include banded quartz veins, massive quartz veins and stockworks. Samples representing all the different mineralization styles were collected from all three vein systems in the Guanajuato mining district and the mineral textures and fluid inclusion characteristics have been defined.

Laser ablation ICPMS analysis of 5 samples from a Au-rich zone in the Veta Madre system shows that the gold occurs mostly as electrum, with lesser amounts contained in pyrite. Jigsaw texture silica is observed in all samples and is spatially related to the electrum. Coexisting liquid-rich and vapor-rich fluid inclusion assemblages are present in all samples and vapor-rich-only inclusion assemblages (providing evidence for flashing of the fluids) are present in most samples. The fluid inclusions are hosted by jigsaw texture quartz in secoundary fluid inclusion assemblages. Calcite appears both as bladed and rhombic crystals and the bladed variety contains coexisting liquid-rich and vapor-rich and vapor-rich-only inclusion assemblages. The presence of jigsaw textured quartz and/or bladed calcite is closely associated with precious metal mineralization in the Veta Madre, and provides a useful tool to help the explorationist focus on veins that have potential to hostn economic minerlization.

Sulfur cycling in a high-sulfide tailings impoundment

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When exposed to the atmosphere, sulfide-rich mine tailings oxidize and release acid and metals to tailings pore waters. Discharge of this metal-rich water can lead to severe degradation of water quality in receiving lakes and streams. The former Sherritt-Gordon Zn-Cu Mine, located in Sherridon, Manitoba, Canada, deposited high-sulfide tailings into the Woods Lake Tailings Impoundment between 1937 to 1951. The tailings cover an area of 40 ha, completely filling nearby Trap Lake and partially filling Woods Lake that contains organic-bearing detrital bottom sediments. Over the past half century, microbially mediated sulfide oxidation reactions have led to the depletion of sulfides (δ^{34}S-SO_4: 0.2 to 1.2 ‰) in the upper 40 cm of the tailings. Consequently, concentrations of sulfide oxidation products are very high in the unsaturated tailings pore water (Fe: 107 g/L, SO_4: 244 g/L, Zn: 4.8 g/L, Cu: 1.1 g/L, and pH: 0.67), with highest concentrations of metals and lowest pH conditions present in the zone of active oxidation. At the border between the tailings and Woods Lake concentrations of metals and SO_4 decrease. This decrease coincides with significant sulfur isotope fractionation with depth (δ^{34}S-SO_4 29.4‰), suggesting that the decrease in concentrations is due to bacterially mediated (dissimilatory) sulfate reduction, not dilution. Additional indicators of bacterial sulfate reduction include: increased pH, alkalinity, dissolved H_2S, production of methane and decreased Eh with depth. Saturation indices calculated using the equilibrium/mass transfer model MINTEQA2 suggest that secondary sulfide minerals are potentially precipitating in the zone of bacterial sulfate reduction controlling sufate and metal mobility. During mineralogical studies, the occurrence of seconday covellite was observed in reduced areas of the tailings. Presently bacterial sulfate reduction occurring at the tailings edge appears to lead to a substantial decrease in loading of dissolved metals, sulfate and low pH groundwater to Woods Lake. However, metal loadings may increase if the underlying organic-rich lake sediment, which is utilized as a carbon source for bacterial sulfate reduction, is exhausted.