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Monitoring mechanisms that control gold precipitation from auriferous fluids

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During orogenic gold mineralization, the mechanisms by which a hydrothermal fluid precipitates gold in sulfide-bearing quartz-carbonate shear veins remains elusive; however, due their small footprint, this understanding is critical for targeting high-grade veins. Reduced, near-neutral auriferous fluids, commonly ascend along deep structural corridors located in the middle crust, and transport gold as reduced bi-sulfide complex, such as $Au(HS)_2^-$. The subsequent precipitation of gold from hydrothermal fluids is best interpreted as the product of an evolving fluid SO_4/H_2S ratio (fO_2) and/or H_2S concentration (fS_2), each a function of processes such as fluid mixing, fluid-wall rock reaction, and/or phase separation. Recent developments in analytical techniques allow for in-situ multiple sulfur isotopes and trace element composition analyses through a sulfide-paragenetic sequence, providing insight into the evolving physico-chemical fluid processes that lead to the destabilization of gold-complexes.

In this keynote talk, we demonstrate applications of in-situ $\delta^{34}S$-$\delta^{33}S$ combined with trace element data through gold-bearing sulfide parageneses, with examples from orogenic gold deposits of the Abitibi subprovince, Canada, and Eastern Goldfields, Australia. Quartz-carbonate-tourmaline veins of the Triangle deposit (Abitibi) hosts gold as 10-100 µm-sized Bi-Te-Au-Ag inclusions within pyrite. This pyrite generation preserves limited within-grain zonation in $\delta^{34}S$ (~3 ± 1.5‰) and As (Ë,200 ppm), Te (<250 ppm), Bi (<300 ppm) contents. We interpret this signature to indicate that gold precipitated by a reduction in fluid fS_2, induced by wall-rock sulfidation of Fe-enriched host rocks. Conversely, quartz veins of the Kanowna Belle deposit (Eastern Goldfields) preserve lattice-bound and nano-inclusions of gold within oscillatory-zoned pyrite rims. Pyrite grains record Au-poor cores and Au-rich rims coincident with core to rim shifts in $\delta^{34}S$ (from 0 to -8‰), while retaining a constant $+\delta^{33}S$ value, and rim enrichment in As (to 4.5 wt%) and Te (to 830 ppm) contents. We interpret this signature to indicate that gold precipitated during H_2 vaporization from the fluid, thereby increasing the SO_4/H_2S ratio and destabilizing gold complexes, allowing Au to enter As-enriched Fe crystallographic sites. By understanding the different isotopic and chemical signatures associated with gold precipitation mechanisms, we can better predict the criteria controlling where high-grade gold±bismuth-tellurium anomalies are located in the crust.