

Gold Beyond Arsenian Pyrite: A Redox-Controlled Shift in Carlin-Type Mineralization

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Eocene Carlin-type gold deposits are known for “invisible” gold hosted in arsenian pyrite or in arsenian-pyrite overgrowths on barren pyrite. The main-stage mineralization at the Leeville District is defined by arsenian pyrite precipitation and an alteration assemblage consisting of muscovite+illite±kaolinite±dolomite±fluorapatite. This assemblage is locally overprinted by disseminated orpiment±fluorite and a later assemblage characterized by veinlet-hosted calcite±barite±realgar±kaolinite±dolomite±quartz±fluorite±scheelite.

Our paragenetic study at the Leeville District shows that disseminated orpiment encapsulates earlier arsenian pyrite and locally exhibiting replacement textures. Orpiment subsequently precipitates along veinlets, followed by realgar within calcite ± barite veinlets. Once the system shifts to orpiment and realgar precipitation, no Fe-bearing sulfide precipitates.

Electron microprobe analysis (EMPA) on realgar and orpiment from the Leeville deposit demonstrates that these minerals can host comparable amounts of gold (up to 0.57 wt.% of Au in realgar and 0.32 wt.% of Au in orpiment) as arsenian pyrite (avg. 0.15-0.18 wt. % of Au). Only Hg accompanies Au in orpiment and realgar, whereas Sb and Tl are commonly below detection limits and Cu is typically < 0.1 wt. %.

At Leeville, realgar and orpiment occur in rocks that were first diagenetically altered to dolomite+K-Ba-bearing feldspars and later hornfelsed during the Jurassic to an assemblage of calcite+diopside±biotite±phlogopite. Arsenian pyrite in this area is finer-grained, commonly needle-like, and shows fewer concentric overgrowths than in other areas. Fe-bearing silicates and carbonates are partly preserved and lack complete replacement by gold-bearing pyrite, suggesting that wall-rock sulfidation was not the primary trigger for gold precipitation in this part of the system.

Combined with previous studies of As speciation in arsenian pyrite, our observations suggest that the system evolved from As-1 replacing sulfur in pyrite to As+3 stabilizing in realgar and orpiment, while the mineralized system remained capable of transporting and precipitating gold.