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"Invisible" gold revealed: Direct imaging of gold nanoparticles in a Carlin-type deposit

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ABSTRACT

Although As-rich, hydrothermal overgrowths on pyrite have been recognized as the primary host phase for Au in Carlin-type deposits in Nevada, the chemical and structural state of the Au has remained unresolved. Spectroscopic and electron imaging techniques have suggested that Au is either structurally bound (e.g., Au^{1+}) or occurs as particles of native Au (Au^0), but the latter has never been observed directly. We have determined that Au is present in significant quantities as discrete nanoparticles of native Au (~5–10 nm) in As-rich overgrowths on pyrite from the Screamer deposit in the Carlin trend, Nevada, using analytical and high-resolution TEM and high-angle annular dark-field (HAADF) imaging in STEM mode. Electron microprobe and secondary ion mass spectrometry (SIMS) analyses of the As-rich rims containing the Au-particles reveal that these rims (1–20 μm) contain up to 0.8 wt% Au, among the highest Au-contents ever reported for arsenian pyrite. These observations suggest two possible mechanisms for nanoparticle formation: that Au exceeded its solubility limit in arsenian pyrite causing it to be deposited as nanoparticles of native metal; or that exsolution of native metal from metastable arsenian pyrite was caused by a later event in the history of the deposit.