

Oldest Gold: Deformation and Hydrothermal Alteration in the Early Archean Shear Zone-Hosted Bamboo Creek Deposit, Pilbara, Western Australia

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Abstract

The Early Archean Bamboo Creek gold deposit contrasts with most other orogenic deposits because of its relatively early timing in the tectonic evolution of the Pilbara granitoid-greenstone terrane.

The Bamboo Creek deposit is situated in a bedding-parallel, brittle-ductile shear zone (the Bamboo Creek shear zone) within a komatiite sequence. The laminated quartz-carbonate gold lodes occur in carbonate-altered boudins within the Bamboo Creek shear zone and are associated with early sinistral, northeast-up deformation in the shear zone, whereas dextral reactivation of the zone postdates gold deposition. Gold-related alteration zones reflect an increase in X_{CO_2} toward the mineralized zone. Variations in original host-rock composition give rise to asymmetric alteration zoning, with a fuchsite-carbonate zone in the more Mg- and Cr-rich cumulate-textured footwall and a chlorite-quartz zone in the more aluminous spinifex-textured hanging wall. The alteration envelope is enriched in Na_2O , K_2O , Rb, Pb, As, and Sb. Whereas pyrite and minor chalcopyrite occur in all alteration zones, tetrahedrite, galena, and sphalerite are strongly associated with gold in the lodes. The alteration and metal enrichment of the Bamboo Creek gold deposit are indistinguishable from those of other orogenic (mesothermal) lode gold deposits in Archean terranes. Carbonate $\delta^{13}\text{C}_{(\text{PDB})}$ and $\delta^{18}\text{O}_{(\text{SMOW})}$ isotope signatures are consistent throughout the alteration envelope at 0.2 ± 0.6 and 14.6 ± 0.6 per mil, respectively. The $\delta^{13}\text{C}$ value, in particular, is higher than typical values for orogenic gold deposits, implying interaction of auriferous fluids with preexisting marine carbonates that formed during an early sea-floor alteration event. The temperature of deposition, estimated from chlorite thermometry and alteration assemblages, is about 250°C, which is within the lower part of the range for orogenic gold deposits.

Lead-lead model ages for galena, together with the relationships between the Bamboo Creek shear zone and dated granites, indicate a relatively early age of gold deposition of ca. 3400 Ma. Correlation of structures associated with gold deposition and regional structural phases shows that gold deposition was most likely related to an extensional tectonic phase. The early timing and association with extension is unlike the tectonic setting of other Archean gold deposits, which tend to form during the final, compressional or strike-slip stages of orogenesis. The Bamboo Creek gold mineralization may have been related to an Early Archean lower crustal delamination event. This may explain the anomalous timing and the low gold endowment of the Pilbara relative to Late Archean greenstones.