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The Role of a Transcrustal Shear Zone in Orogenic Gold Mineralization at the Ajjanahalli Mine, Dharwar Craton, South India

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Abstract

The Ajjanahalli gold mine is spatially associated with a Late Archean craton-scale shear zone in the eastern Chitradurga greenstone belt of the Dharwar craton, India. Gold mineralization is hosted by an ~100-m-wide antiform in a banded iron formation. Original magnetite and siderite are replaced by a peak metamorphic alteration assemblage of chlorite, stilpnomelane, minnesotaite, sericite, ankerite, arsenopyrite, pyrite, pyrrhotite, and gold at ca. 300° to 350°C. Elements enriched in the banded iron formation include Ca, Mg, C, S, Au, As, Bi, Cu, Sb, Zn, Pb, Se, Ag, and Te, whereas in the wall rocks As, Cu, Zn, Bi, Ag, and Au are only slightly enriched. Strontium correlates with CaO, MgO, CO_2, and As, which indicates cogenetic formation of arsenopyrite and Mg-Ca carbonates. The greater extent of alteration in the Fe-rich banded iron formation layers than in the wall rock reflects the greater reactivity of the banded iron formation layers. The ore fluids, as interpreted from their isotopic composition ($\delta^{18}O$ = 6.5–8.5‰; initial $^{87}Sr/^{86}Sr$ = 0.7068–0.7078), formed by metamorphic devolatilization of deeper levels of the Chitradurga greenstone belt. Arsenopyrite, chalcopyrite, and pyrrhotite have $\delta^{34}S$ values within a narrow range between 2.1 and 2.7 per mil, consistent with a sulfur source in Chitradurga greenstone belt lithologies. Based on spatial and temporal relationships between mineralization, local structure development, and sinistral strike-slip deformation in the shear zone at the eastern contact of the Chitradurga greenstone belt, we suggest that the Ajjanahalli gold mineralization formed by fluid infiltration into a low strain area within the first-order structure. The ore fluids were transported along this shear zone into relatively shallow crustal levels during lateral terrane accretion and a change from thrust to transcurrent tectonics. Based on this model of fluid flow, exploration should focus on similar low strain areas or potentially connected higher order splays of the first-order shear zone.

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