

# Fluid Chemical Evolution as a Factor in Controlling the Distribution of Gold at the Archean Golden Crown Lode Gold Deposit, Murchison Province, Western Australia

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## Abstract

The Golden Crown lode gold deposit is one of a number of northwest-southeast- to north-south-trending quartz veins hosted by a steeply dipping, 500-m-thick, differentiated dolerite sill (the Great Fingall sill) and adjacent graphitic shale in the Day Dawn district of the Murchison province in the Archean Yilgarn craton, Western Australia. Quartz veins of the Golden Crown deposit are shear zone-hosted, crosscut the dominant host-rock stratigraphy at a high angle, and are laminated, partly boudinaged, and generally bifurcate at their extremities. Veins are dominated by dark gray or milky white quartz, with subordinate calcite and ankerite, and, in order of abundance, arsenopyrite, pyrrhotite, pyrite, galena, chalcopyrite, and minor sphalerite. The vein sulfides coexist with native gold and are most abundant at vein margins. Textural evidence indicates that precipitation of the majority of these minerals overlapped, and that most phases can be considered to have been in equilibrium during vein genesis.

Mineral chemistry, fluid inclusions, alteration, and ore assemblages show that there are significant systematic gradients in intensive variables within the Golden Crown deposit. These are recorded over the approximately 450 m of vertical exposure of the vein system, and over up to 30 m into the wall rocks. Based on proximal alteration assemblages and zoning patterns, zoned wall-rock alteration haloes are divisible into four sequences, three of which are closely related to gold mineralization. Specific alteration sequences occur within different parts of the vein system. Biotite alteration predominates in the deeper portions, whereas muscovite alteration characterizes the upper and southern portions of the system. Higher-grade gold zones within the Golden Crown deposit are limited to the northern end of the system in the deeper portion of the veins, and expand along strike to the south in the upper portions.

Fluid inclusions, interpreted to be trapped during gold mineralization, are low-salinity (<10 wt % NaCl equiv) H<sub>2</sub>O-CO<sub>2</sub> ± CH<sub>4</sub> inclusions with variable carbonic to aqueous contents that are interpreted to be due to fluid immiscibility. Inferred methane concentrations in the carbonic phase vary significantly from 19 ± 7 mole percent in the vicinity of the shale contact to 5 ± 2 mole percent in the shallower, southern end of the deposit. Carbon and oxygen isotope compositions of carbonates ( $\delta^{13}\text{C}_{\text{calcite}} = -10.5$  to  $-1.9\text{‰}$ ;  $\delta^{13}\text{C}_{\text{ankerite}} = -5.3$  to  $-4.1\text{‰}$ ;  $\delta^{18}\text{O}_{\text{calcite}} = 7.0$ – $18.3\text{‰}$ ; and  $\delta^{18}\text{O}_{\text{ankerite}} = 7.7$ – $9.2\text{‰}$ ) and oxygen isotope compositions of vein quartz ( $\delta^{18}\text{O}_{\text{quartz}} = 10.2$ – $12.5\text{‰}$ ) are well within the range of known Archean orogenic lode gold deposits. Combining the results of all geothermometers and geobarometers, a temperature of 300° to 400°C and pressure of 2.5 ± 0.5 kbars are determined, with temperature variations over the exposed quartz vein of less than 40°C. The As content (at. %) of arsenopyrite and Au/Ag ratios of native gold show significant compositional variation, which appears to be controlled by parameters such as  $a_{\text{H}_2\text{S}_{(\text{aq})}}$  and  $f_{\text{O}_2}$ , not temperature gradients.

On the basis of the variations in fluid composition determined in the reefs, the two major processes responsible for high-grade gold mineralization are interpreted to have been phase separation in the deeper portions of the ore-forming system (approximately below -400-m level) and, above these levels, mixing between two modified ore fluids, one reduced fluid that had reacted with graphitic shale and a relatively oxidized fluid that had partly equilibrated with dolerite.