Gold mineralization at the Hardrock orogenic gold deposit, Geraldton, ON: structural controls, mineralogy, and geochemical footprints

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The Hardrock orogenic gold deposit is located in the Beardmore-Geraldton greenstone belt (BGB), which stretches along the boundary between the granite-greenstone Wabigoon subprovince and the metasedimentary Quetico subprovince of the Archean Superior Province. Over 4.1 Moz of gold were produced from several mines across the BGB over the past century. For decades, very limited exploration took place in the area and the conducted research focused on the accessible surface exposures. Only one comprehensive study was completed on the gold mineralization in the Geraldton area at the end of the 1980's. Over the last decade, new exploration outlined 4.87 Moz Au indicated and 2.74 Moz Au inferred resources at the Hardrock deposit, near Geraldton. This renewed exploration has resulted in large, freshly stripped, gold-mineralized exposures and hundreds of new drill holes that provide new opportunities to better understand the controls and characteristics of the gold mineralization using modern analytical techniques. Two stages of mineralization are recognized at the deposit, an early event during D_1 thrusting and a second during D_2 sinistral transpression, which are associated with three vein sets hosted by lower-order structures along the belt-bounding high-strain zones. The strongly folded, early-D_1 (V_1) and linear, syn-D_2 (V_3) quartz-carbonate veins have similar sericite-carbonate-sulfide alteration halos in turbiditic metasedimentary rocks and banded iron formation, whereas their alteration halos are composed of carbonate, albite and pyrite in feldspar-quartz porphyry. A second syn-D_2 linear vein set (V_2) composed predominantly of tourmaline and quartz is surrounded by carbonate-tourmaline-sulfide alteration halo in clastic metasedimentary rocks. Visible gold occurs in the vein sets and as inclusions or along fractures in the pyrite and arsenopyrite in the alteration. Furthermore, gold is bound in the lattice of inclusion-rich pyrite grains that are characterized by elevated Ag-Bi-Pb-Sb-Te concentrations. The overall geochemical footprint is complex and varies with the host rock. The geochemical footprint accompanying the gold mineralization is characterized by S-W-As-Bi-Te-Mo±Se±Sb±K_2O±FeO enrichment in turbiditic metasedimentary rocks, by Pb-S-FeO-Bi-Ag-As-Te enrichment in banded iron formation and by W-As-Te-S-enrichment in the feldspar-quartz porphyry. Our research found that gold-mineralizing hydrothermal processes were active over at least two deformation events and resulted in both strongly folded and linear auriferous veins, yet the mineral assemblages and geochemical footprints associated with the two stages of mineralization are similar.