

The Canadian Malartic World-class Gold Deposit: Toward a Multiphase Model for Archean sediment- and porphyry-hosted Low-Grade large tonnage Gold Deposits

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Abstract

The Canadian Malartic gold mine (10.9Moz, 345Mt@0.98 g/t) is mainly hosted by Pontiac Goup greywacke and ca. ≤ 2678 Ma sub-alkaline to transitional porphyritic monzodiorite located immediately south of the Larder-Lake–Cadillac Fault Zone. The main cleavage (S_2) in the Pontiac Group is NW-striking and axial-planar to F_2 folds. Ore zones are dominantly oriented according to NW-SE and E-W trends, and are sub-parallel to S_2 and to the Sladen Fault. Ore minerals comprise pyrite+tellurides±sphalerite±chalcopyrite±galena, and molybdenite, which yielded a ca. 2664 Ma Re-Os age. Bi-Te-W-S-Ag±Pb±Mo defines the bulk metallic signature. Monzodiorite in the footwall of the Salden Fault shows an early distal reddish-coloured calcite+hematite+biotite±pyrite assemblage that is overprinted by proximal greyish-coloured replacement zones comprising microcline+carbonate+albite+rutile±biotite. These alterations show significant K_2O , CO_2 , and S progressive mass gains from the distal to proximal assemblages. Auriferous pegmatitic carbonate-feldspar-biotite-muscovite-tourmaline-scheelite veins are locally superimposed on these alteration zones. In the hanging-wall of the Sladen fault and along NW-SE ore zones, the greywacke shows distal calcite+biotite and proximal albite-microcline-quartz-pyrite±biotite±calcite alteration assemblages. These occur as bedding- and shear zone-controlled replacement zones, and as thin selvages of quartz-calcite-biotite veinlets preferably developed in the hinge zone of F_2 folds. Proximal alteration shows consistent Na_2O , CO_2 and S gain, whereas K_2O shows variable gain/loss. Quartz-pyrite-galena laminated and breccia veins with visible gold are locally present and overprint these alteration assemblages. Biotite in the mineralized alteration zones (greywacke and monzodiorite) is F- and Mg-rich, contrasting with the background biotite, defining hydrothermal/exploration vectors. Our study reveals that the deposit results of the superposition of hydrothermal and structural events including a ≤ 2678 Ma syn-Timiskaming magmatic-hydrothermal phase inferred by the metallic signature, presence of mineralized stockwork and potassic alteration (biotite/microcline). This phase shares analogies with Archean syenite-associated disseminated gold deposits. However, at least part of the mineralization and its distribution are controlled by syn-D2 structures, as indicated by the chronology of alteration/deformation and the ca. 2664 Re-Os molybdenite age.