

An Updated Genetic Model for the Kirkland Lake Gold Mineralization (Ontario, Canada): An Intrusion-Related System with an Orogenic Overprint

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The Macassa mine in the Kirkland Lake gold camp of the southern Abitibi greenstone belt has been one of the world's highest-grade producers since its opening in 1933. Historic workings exploited vein-hosted orebodies along major faults north of the Larder Lake – Cadillac deformation zone, while present production focuses on the South Mine Complex (SMC), discovered in 2005, where mineralization is linked to sulfidation and centered on monzodioritic intrusive bodies (“basic” and “porphyry syenite”). Traditionally regarded as an orogenic gold system, the new discovery prompted the re-assessment of the deposit model to improve brownfields and regional exploration tools. The following results focus on the ore system aspect of the deposit as part of a comprehensive study that aims to redefine the structural, stratigraphic and geochemical framework of the camp.

The (calc-)alkaline intrusions of the Kirkland Lake system originated from an oxidizing magma source where segregated fluids caused high-temperature, deuteric potassic (biotite-magnetite-K-feldspar) alteration of the deeper seated basic syenite and a hydrothermal potassic (biotite-magnetite) overprint of the porphyry syenite and host rocks. This stage is represented by Au(-Cu) mineralization in basic syenite with temperatures around 500 °C near the MH buffer (chalcopyrite-hematite±bornite±anhydrite). With gradual drop of temperatures and fO_2 , sulfidation accompanied by potassic (K-feldspar) and phyllic (sericite) alteration through magnetite-biotite breakdown became the typical SMC mineralization process. Based on pathfinder ratios (Bi/Hg vs Te/As) and chronostratigraphy, the near-surface AK deposit in the footwall of the south bounding fault may be a lateral satellite of the same system. Intense pervasive sericite alteration and fabric development during D_3 deformation overprint the SMC and AK zones, which is an atypical relative age for orogenic gold deposits along the Larder Lake – Cadillac structural corridor. These observations suggest a hybrid system with an early intrusion-related and a subsequent orogenic component.