

Gaillard N, Williams-Jones AE, Clark JR, Lypaczewski P, Salvi S, Perrouty S, Piette-Lauzière N, Guilmette C, Linnen RL, 2018, Mica composition as a vector to gold mineralization: deciphering hydrothermal and metamorphic effects in the Malartic district, Quebec, *Ore Geology Reviews*, 95, 789-820

Canadian Malartic, with a total endowment of 16.3 Moz Au, is an important example of a large-tonnage, low-grade Archean gold deposit (current reserves of 204 Mt @ 1.08 g/t Au). It is located in the southern Superior Province in contact with, and immediately south of the east-west trending Cadillac-Larder Lake fault zone, which delineates the boundary between the Pontiac and Abitibi subprovinces. The deposit is hosted by Pontiac Group metaturbidites, Piché Group mafic-ultramafic metavolcanics and by porphyritic quartz monzodiorite to granodiorite that intruded these lithologies. The metamorphic grade increases southward from upper greenschist facies, which characterizes the immediate metamorphic environment of the Canadian Malartic deposit, to mid-amphibolite facies; the garnet isograd is crossed 1.5 km south of the deposit, and the staurolite isograd about one kilometer further south. Textural, structural and geochronological observations are consistent with a syn-kinematic (D_2), early- to syn-peak metamorphic (M_2) timing for the main ore-forming event. Mineralization in the metasedimentary rocks and porphyritic intrusions consists of disseminated native gold and minor gold-tellurides within stockworks of quartz-biotite-microcline-carbonate±pyrite veinlets (v_2) and associated pervasive microcline-albite-biotite±(white mica)-carbonate-pyrite alteration. A zonal distribution of alteration is centered on structures that acted as preferential pathways for the hydrothermal fluids (e.g., Sladen Fault, NW-SE deformation zones). In the metasedimentary rocks, the proximal potassic alteration zone is dominated by microcline-albite±quartz with variable proportions of phlogopite (±white mica), carbonate minerals (calcite-ankerite±Fe-dolomite), quartz, pyrite and rutile. It grades outwards into a distal potassic-sericitic alteration zone characterized by relatively abundant Mg-rich biotite and phengitic white mica, as well as microcline, albite, quartz, calcite, pyrite and rutile. The zonal distribution of alteration features was due in part to a decrease in the total activity of sulfur species (ΣaS) and oxygen fugacity (fO_2) away from the main hydrothermal corridors, which is manifested by systematic changes in Fe-sulfide and (Fe-Ti)-oxide mineralogy. The effects of sulfidation (ΣaS), oxidation (fO_2) as well as K^+ , Fe^{2+} and H^+ activity on biotite and white mica compositions were assessed from silicate-oxide-sulfide equilibria. Increasing ΣaS - fO_2 conditions proximal to the hydrothermal fluid pathways caused pyrite to be stabilized over biotite, and iron sequestration in the sulfide phase in turn promoted the stability of magnesian biotite. Increasing sulfur metasomatism towards the hydrothermal centers was associated with systematic increases in biotite Mg# [$Mg/(Fe_{total}+Mg)$] and fluorine concentration, in agreement with the Fe-F avoidance principle. Alteration was also associated with a decrease in Al in biotite and white mica, coincident with increases in Si and Fe+Mg concentrations. These compositional trends were controlled by a Tschermak exchange reaction and are consistent with a gradual decrease in a K^+ and/or pH upon progressive rock-buffering of a mildly alkaline, potassium-rich ore-forming fluid. Multicomponent phase equilibria (pseudosections), constrained for specified bulk rock compositions typical of non-mineralized Pontiac Group metasedimentary rocks, are used to model the expected composition of mica solid solutions under varying metamorphic P-T conditions. The thermodynamic modelling of biotite and white mica compositions suggests that the district-scale compositional trends documented for biotite and white mica along the metamorphic gradient, including the progression of the Tschermak substitution towards more aluminous compositions southwards, were likely the product of increasing metamorphic P-T conditions, rather than a distal effect of hydrothermal alteration. Mica mineral chemistry is clearly a sensitive indicator of hydrothermal and metamorphic processes at Canadian Malartic. Our results show that biotite and white mica compositions provide valuable tools that can be used to define hydrothermal fluid pathways in and around the deposit. These factors should be particularly useful for mapping the zonation of alteration features that characterize the footprint of major gold deposits in metamorphic terranes where micas typically display a spatial distribution ideal for defining mineral-chemical vectors to ore.

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