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Detecting different types of ore-forming fluids at Archean gold deposits using reflectance spectroscopy

Rui Wang*, Carsten Laukamp, Thomas Cudahy, John L. Walshe, and Adam Bath

*e-mail, Rui.Wang@csiro.au

Two greenschist facies Archean gold deposits in the Eastern Goldfields of Western Australia with contrasting variations in white mica Al-Si chemistry (Tschermak substitution) were selected for study using short-wave infrared (SWIR) spectrometry, focusing on the wavelength of the white mica-related absorptions positioned between 2190 and 2220 nm. The >10M ounce gold systems of Kanowna Belle and Sunrise Dam represent structurally-controlled, hydrothermal deposits with broadly similar host rocks and alteration halos that extend for 0.5 to 1.5 km from the economic zone. Gold mineralization at Kanowna Belle is associated with phengitic white mica showing elevated levels of silica, as well as quartz, chalcopyrite, and pyrite with negative $\delta^{34}S$, and a relative lack of carbonate, chlorite, and paragonite. In contrast, gold mineralization at Sunrise Dam is associated with paragonitic white mica with low levels of silica as well as carbonate, Fe-rich chlorite, and pyrite with positive $\delta^{34}S$, and a relative lack of quartz and chalcopyrite. Laboratory geochemical analyses show that the change in 2200 nm absorption wavelength is proportional to the amount of tetrahedral Si and inversely correlated with the tetrahedral and octahedral Al contents, confirming previous work. Thermodynamic numerical modelling indicates that these changes in white mica Tschermak substitution can be explained by two different types of ore fluids. At Kanowna Belle, oxidized, alkaline and silica-rich ore fluids resulted in formation of phengitic micas proximal to gold mineralization, whereas reduced, acid, Fe-rich, and silica-poor fluids at Sunrise Dam lead to dominantly paragonitic micas. Importantly, this study shows that spectral detection of a gradient of 2190-2220nm in white mica Tschermak substitution composition, coupled with identification of other key alteration minerals (quartz, chlorite, carbonate, pyrite), can be used to measure and map alteration zones as a vector towards hydrothermal gold deposits.