Spectral induced polarization signatures of altered metasedimentary rocks of the Canadian Malartic gold deposit Bravo zone, Quebec, Canada

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Electrical geophysical methods such as time-domain induced polarization (TDIP) are traditionally used in prospecting for sulfide-associated ore deposits. However, previous TDIP surveys conducted over the Canadian Malartic deposit, where gold occurs as fine native grains or inclusions in micrometer to sub-millimeter scale pyrite grains, have failed to delineate known areas of pyrite alteration in the Archean metasedimentary host rock. Using an innovative approach to define the petrophysical footprint of Canadian Malartic, spectral induced polarization (SIP) measurements were conducted both on drill core samples in the laboratory and in the field at the Bravo zone outcrop. SIP data consists of complex resistivity measurements (phase shift and amplitude) in the frequency domain, typically in a range from a few mHz to several kHz. Three groups of SIP spectra are identified and interpreted using Mineral Liberation Analysis of polished thin sections, short-wave infrared spectroscopy, and gamma-ray spectrometry. The first group shows a well-defined phase peak between 1 and 10 Hz. It is associated with altered metagreywacke, characterized by pyrite enrichment, gold mineralization, and induration that is the result of microcline, albite, and quartz alteration. The second group is associated with non-mineralized metagreywacke in which pyrrhotite replaces pyrite as the main sulfide. It displays no obvious phase peaks in the 10 mHz – 10 kHz range. The last group has increasing phase shift with decreasing frequency, with a polarization peak below 10 mHz. It corresponds to sedimentary beds of graphitic mudstone composition and ilmenite-rich monzodiorite intrusions. Finally, Bayesian inference of SIP parameters using a Warburg decomposition model is performed. Values of total chargeability (Σm) and mean relaxation time ($\acute{\tau}$) are used to characterize the respective SIP signatures of ilmenite-rich monzodiorite and graphitic mudstones ($\acute{\tau}=0.10\,s$ and $\Sigma m>15$), gold-mineralized altered metagreywacke ($\acute{\tau}=0.05\,s$ and $\Sigma m<10$), and barren metagreywacke ($\acute{\tau}<0.03\,s$ with variable Σm). CMIC-NSERC Exploration Footprints Network Contribution 121.