Geophysical Research Abstracts
Vol. 21, EGU2019-11255, 2019
EGU General Assembly 2019

Investigating the potential of the seismic reflection method for imaging hydrothermal conduits: a case study from the Lalor volcanogenic massive sulphide deposit, Snow Lake, Manitoba, Canada

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The seismic reflection method has been successfully applied in imaging volcanogenic massive sulphide (VMS) deposits, which is attributable to the high acoustic impedance contrast between massive sulphide ore and their volcanogenic host rocks. Although direct detection of sulphide ore will likely remain a primary objective, seismic imaging of the more voluminous hydrothermal alteration zones, which mark the conduits along which mineralized fluids ascended, widens the scope of seismic exploration as the depth of new discoveries is increasing.

Integrated analyses of seismic rock properties, lithogeochemistry and mineral abundances of drill core from the Lalor VMS deposit, Snow Lake, Manitoba, Canada are presented, which not only considers seismic reflectivity of contacts between sulphide ore and host rock units, but also seismic reflectivity at contacts with hydrothermal feeder conduits. Multivariate analysis of geochemical alteration indices and seismic rock properties shows an increase in P-wave velocity with increasing intensity of alteration, particularly in volcanic precursors of intermediate and mafic composition. SEM-EDS analyses of drill core samples suggest that this P-wave velocity increase is due to the high abundance of cordierite, garnet and anthophyllite, constituents of amphibolite facies assemblages that are unique to the metamorphosed and intensely-altered footwall of the massive sulphide ore lenses. 2D seismic synthetics of a VMS deposit model, which includes a discordant conduit of this mineral composition, shows enhanced reflectivity from its contacts with unaltered mafic and felsic host rocks. Collectively, the results suggest that greenstone belt domains metamorphosed in the amphibolite facies have enhanced potential for seismic detection of VMS-related hydrothermal alteration.