Unraveling Bulk-rock Compositional and Metamorphic Mineral Assemblage Zoning at the Laronde Penna Volcanogenic Massive Sulfide Deposit

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This study introduces a workflow that was developed to identify geochemical and mineralogical gradients in ore deposits by non-destructive drill core analysis. This was achieved by compositional analysis of drill core by continuous XRF core scanning using the device manufactured by Minalyze AB and conducting short- and long-wave hyperspectral imaging of the core using instrumentation at Terracore in Reno, Nevada. Both datasets were co-registered to allow cluster analysis. Based on the clustering, a subsampling strategy was developed to allow further petrographic investigations on representative thin sections and automated mineralogical analysis.

The workflow developed was tested on drill core from the LaRonde Penna deposit in the Archean Abitibi greenstone belt in Quebec. The deposit is a world-class gold-rich volcanogenic massive sulfide deposit which contains an endowment of 71 Mt of ore grading on average 3.9 g/t Au. The ore lenses and their host rocks have been affected by regional greenschist to lower amphibolite facies metamorphism.

The study of core from LaRonde Penna demonstrates that the metamorphoses hydrothermal alteration halo is strongly zoned. Whole-rock geochemical variations along core intersecting the alteration halo and ore zones closely correlate with metamorphic mineral assemblage zoning. The observed variations in the composition of the felsic volcanic rocks in the footwall of the massive sulfide lenses were introduced during hydrothermal alteration as the intensity of fluid-rock interaction was most pronounced in proximity to the ore zones and decreased outwards away from the major zones of hydrothermal upflow. The composition of the hydrothermally altered rocks controlled metamorphic mineral assemblage formation during subsequent metamorphism.

The research has implications to mineral exploration for VMS deposits in high-grade metamorphic terrains as it establishes the link between whole-rock geochemical gradients and metamorphic mineral assemblage variations at greenschist to amphibolite metamorphic grade