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Zinc Sulfide Mineralization Hosted in Marbles of the Proterozoic Grenville Supergroup, Canada: Implications for Base Metal Exploration in High-Grade Terranes

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The demand for zinc is expected to exceed supply this decade, unless new deposits are discovered. Over the course of the past century, the success of discovered mineral deposits has decreased, making it more important to expand our knowledge of exploration to cover complex terranes such as those of high metamorphic grade. This study examines marble-hosted zinc in the high-grade metamorphosed Proterozoic Grenville supergroup at the Salerno Lake and Calumet-Sud occurrences of Ontario and Quebec. The purpose of this study is to determine the stratigraphic controls and characteristics of the multiple styles of mineralization present at these two locations in comparison to other local sediment-hosted zinc deposits. The carbonate sequences of the southeastern Central Metasedimentary Belt (CMB) in the Grenville Province host several zinc deposits and occurrences (e.g., Balmat-Edwards, Franklin and Sterling Hill, Renprior/Cadieux, Calumet-Sud, Salerno Lake, Long Lake, Maniwaki). Most of the zinc mineralization is hosted in high-grade metamorphosed dolomitic (and locally calcitic) marbles, regionally controlled by the basin-margin faults that border the CMB, containing calc-silicate minerals such as diopside, tremolite, serpentine, phlogopite, and talc. The sulfide zinc deposits have been interpreted to have been formed from exhalative brines during sedimentation of the carbonate sequence (SEDEX deposits). However, the results from detailed mapping, paragenesis, mineral chemistry, and lithogeochemistry at the Salerno Lake (Ontario) and Calumet-Sud (Quebec) occurrences revealed that syenite, carbonatite, and felsic intrusions occur proximal to and may have contributed to the zinc mineralization.

At the Salerno Lake occurrence, yellow (Fe- and Mn-poor), intrusion-proximal sphalerite is associated with apatite displaying elevated concentrations of F, Na_2O, and SO_3, similar to apatite in the intrusive rocks. Moreover, both the proximal hydrothermally altered marble and meta-syenite intrusion contain elevated K_2O, Al_2O, TiO_2, Ba, Sr, Rb, Ce, and Nd. Red sphalerite (Fe- and Cd-richer) occurs as overgrowths on yellow sphalerite in the proximal zones, extends along bands in the distal zones, and is associated with apatite and graphite. Calumet-Sud shares similar mineralogical relationships. It is proposed that the marble-hosted zinc mineralization is epigenetic and had input of fluids that exsolved or interacted with the alkaline magmatic rocks, particularly in the proximal zones. The stratabound controls on sphalerite mineralization are interpreted to be due to the interaction of magmatic and possible basinal mineralizing fluids with favorable reduced-carbonate layers rich in organic matter and phosphate. Amphibolite-facies metamorphism and deformation have caused changes in the textures of the ore, but the compositional signature of the mineralized zones is interpreted to represent that of the original hydrothermal system.

This study brings new insights to understand processes related to zinc mineralization in the Grenville Supergroup, revealing the relevance of the association with intrusive rocks, that should be taken into consideration when exploring in similar tectonic/geological setting. Furthermore, it provides a robust approach integrating mineralogy, lithogeochemistry, and mineral chemistry to document processes that occurred prior to high-grade metamorphic conditions, which could be applied as vectors to exploration in high-grade metamorphosed terranes globally.