

Pyrite Geochemistry and Multiple Isotope Controls on Gold Mineralization at the Young-Davidson Deposit, Canada

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The Young-Davidson (YD) Mine is located within the Cadillac–Larder Lake Deformation Zone (CLLDZ) near Matachewan, Ontario, and represents a syenite hosted orogenic gold deposit characterized by extensive hydrothermal alteration. Gold mineralization is primarily hosted by sulphidized syenite associated with strong hematite alteration and quartz veins that cut syenite intrusions. This study aims to identify the pyrite generations linked to gold mineralization and to better understand the sources and evolution of ore forming fluids.

Detailed petrographic characterizations of pyrite by using reflected light microscopy, in situ trace element analysis by LA-ICP-MS and in situ sulfur isotope measurements by secondary ion mass spectrometry (SIMS) were conducted. Preliminary results from sulfur isotope analyses include 650 SIMS spots collected from 62 samples. $\Delta^{33}\text{S}$ values range from -0.2 to $+0.3\text{‰}$, while $\delta^{34}\text{S}$ values vary between -11.5 and $+5.9\text{‰}$. To further characterize the different pyrite generations, trace element concentrations were measured on the same analytical spots using LA-ICP-MS. These datasets are being integrated to determine the source of sulfur and gold and to identify which pyrite generations are genetically associated with gold mineralization.

To further constrain fluid evolution, the study incorporates iron isotope measurements by using femtosecond laser ablation multi-collector ICP-MS (fs-LA-MC-ICP-MS). Iron isotopes can record redox processes and fluid–rock interaction during sulfide precipitation, providing an additional tracer for the physicochemical evolution of hydrothermal systems.

By integrating petrography, trace element geochemistry, sulfur and iron isotopes, this study provides a detailed framework for tracking the evolution of hydrothermal fluids and identifying the sulfide generations associated with gold mineralization at Young-Davidson. This new dataset will improve the understanding of gold transport and precipitation mechanisms in syenite hosted orogenic deposits. Also, it will help with exploration and genetic models of gold deposits in the Abitibi Greenstone Belt.