Enhancing Exploration of Green Energy Transition Metals: Directly Dating Carbonate Vein-Hosted Cu-Au Mineralization

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Developing new mineral deposits hosting copper, gold, and other base metals is of critical importance as countries transition to low-carbon energy technologies. Understanding when and why these metals become enriched in geological settings is central to locating and modelling mineralized systems and reducing the socio-environmental footprint of exploration efforts. In natural settings, many economic metals concentrate through magmatic-hydrothermal fluid processes. During collisional mountain-building events, faults and shear zones are known to act as planes of weakness facilitating the migration of magma and associated fluids up through the crust. Evidence of fluid flow is often preserved in the form of mineralized quartz-carbonate veins.

Establishing temporal controls on low-temperature vein formation has been difficult in the past, as classical isotopic dating methods are typically applied to high-temperature minerals such as zircon. Through recent developments in the application of U-Pb dating to carbonate minerals, it is now possible to date low-temperature fluid flow events in ore deposits for the first time.

This project is focused on ore deposits associated with faults and shear zones in the Canadian Cordillera, using the Llewellyn Fault in northern British Columbia as a case study. In this setting, the accretion of crustal fragments and volcanic arcs onto the western margin of North America over more than 200 million years has resulted in an array of mineralization styles, including Cu-Au porphyry, epithermal, carbonate replacement, and skarn.

Here we present preliminary results that combine field-based mapping of mineralized carbonate veins and breccias, novel geochemical and imaging techniques, and in situ U-Pb carbonate geochronology. The results provide timing constraints for mineralization and faulting, significantly improving our understanding of the timing, rates, and duration of fluid flow and metal (re)distribution in case-study mineral deposits. Ongoing work aims to link timing(s) of mineralization to the broader tectonic and metallogenic framework of this region.