Carbon and oxygen isotopes in carbonate minerals can define cryptic isotopic alteration halos around different mineral deposit types, for which trace element anomalies may not be as easily identified.

MDRU, in partnership with Waikato University and ALS Minerals, offers isotopic measurements of carbonate minerals and rocks using a unique process developed at MDRU. Carbon and oxygen isotopes may have diagnostic alteration signatures in and around ore deposits that are hosted in carbonate rocks or in carbonate mineral alteration and veins. Hydrothermally-altered host rocks surround many ore deposit types, and may contain large, up to km-scale, halos of visibly altered rocks that define the alteration footprints of some ore deposit types (e.g., porphyry and epithermal deposits). In contrast mineral deposits that form in carbonate host rocks typically have narrower and less-intensely developed alteration footprints, and less obvious geochemical footprints. However, carbonate-hosted deposits may have much broader “cryptic” alteration footprints that can be easily detected utilizing light stable isotopes.

The C & O isotopes are measured on gases generated by a weak acid digestion in a specialized instrument developed and modified by the MDRU research team. The instrument is specifically designed to overcome H₂S interferences generated by sulfide-rich samples so that mineralized samples can be analyzed without special pretreatment. Samples can be submitted to directly to MDRU or through ALS Minerals.

Oxygen isotopic ($\delta^{18}$O) composition of syn-mineralization calcite veins around a carbonate replacement deposit shown as a function of distance from the main ore body. The vein oxygen isotopic composition shows an increase of ~7‰ over a distance of 12 km. This type of alteration footprint was previously undetectable, particularly in sulfide-bearing carbonate rocks.

Downhole $\delta^{18}$O variation in a drill core intersecting mineralized and unmineralized zones of a carbonate replacement deposit. Stable isotope alteration of the mineralized carbonate host rock is characterized by a wide range of individual isotope ratios and a general shift to lower values.
New analytical system:
**LGR CCIA-48 Isotope Analyzer**

The new MDRU Mineral Isotope Analyzer is based on Off-Axis Integrated Cavity Output Spectroscopy (OA-ICOS), characterized by relatively low, initial capital cost, low maintenance and requires only inexpensive consumables. It is particularly robust due to the off-axis laser alignment, which provides the potential for deployment in the field and on a mine site.

Light stable isotopes of common elements in ore systems, such as oxygen, carbon, hydrogen, and sulfur, have been used to understand fluid-rock interaction in and around ore deposits for more than half a century. Typically, the relatively “heavy” isotopic values in host rocks are shifted towards lighter values during interactions with hydrothermal fluids. Stable isotope ratios can provide information on fluid flow during hydrothermal ore mineralization, such as mapping the extent of fluid interactions, discerning fracture-controlled vs pervasive fluid flow, determining fluid temperatures, assessing alteration intensity, assessing the source of mineralizing fluids, as well as contributing to the development of ore deposit and exploration models.

Carbon isotope ratios can be used to assess the source of carbon in carbonate minerals (e.g., mantle carbon, sedimentary rock carbon, or biogenic carbon) as well as to assess the role that oxidation may play in hydrothermal systems. Oxygen isotope ratios in carbonate minerals typically vary as a function of the origin of the fluid from which the carbonate mineral formed, as well as the temperature at which the mineral formation took place. Commonly during fluid-rock interaction, the relatively $^{18}$O-enriched host rock will be depleted in $^{18}$O as it interacts with the $^{18}$O-depleted hydrothermal fluid, leaving distinctive isotopic ratios in hydrothermally altered vs unaltered host rocks.

Stable isotopes can be utilized as an exploration targeting tool to 1) identify regions of fluid flow in apparently unaltered rocks to identify targets; and 2) to identify the locations, nature and relative intensity of fluid-rock interactions with prospects to recognize and rank targets within an ore system.

**For More Information:**

**Dr. Greg Dipple**
Professor, MDRU and Earth, Ocean & Atmospheric Sciences, UBC
Expertise in fluid-rock interactions with a focus on driving forces for mineral reactions  
gdipple@eoas.ubc.ca

**Dr. Craig Hart**
MDRU Director
Project management, exploration strategies, and geoscience overview  
chart@eoas.ubc.ca