Ion imaging of biogenic and abiogenic mineral surfaces

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Secondary Ion Mass Spectrometery (SIMS) is ideally suited for studies of elemental and isotopic gradients and the localization of isotopically labelled molecules. The Nano-scale SIMS (NanoSIMS) is the only technique available that can measure isotopic distributions with both high sensitivity (ppm) and high spatial resolution (i.e., 50-1000 nanometres), produce single cell images, and analyse a cell in three dimensions [1, 2]. The following two studies combine the unique capabilities of the NanoSIMS with advanced transmission electron microscopy (TEM) techniques to provide compositional and structural details of biogenic and abiogenic mineral surfaces at the nanoscale [3, 4].

Bio-precipitated minerals are typically at the nanometer scale, hydrous, and beam sensitive. We combined the nano-scale ion imaging capabilities of the NanoSIMS and advanced high-resolution (HR) TEM techniques to characterize the surfaces of *Geobacter sulfurreducens* and the bio-precipitated uranium phases, revealing the association between nutrient uptake and uranium mineral precipitation. Bio-sequestration of uranium is enhanced by addition of nutrients, and uranium is precipitated on the surface of the bacteria as nano-size crystals of uraninite (UO_2). Our results show that the biofilm shielded the UO_2 from re-oxidation and that bacteria can immobilize uranium for extended periods, even under relatively oxidizing subsurface conditions [3].

Nanoscale isotope and chemical images of grains of Amelia albite that were reacted with 2 m ^{18}O-enriched solution of KCl show a correspondence between O-isotope exchange and K-Na exchange. The boundary between the core albite and the K-feldspar replacement is sharp and decorated with numerous pores. The distribution of Na and K, determined by electron probe microanalysis, is uniform within the core and rim and has an abrupt discontinuity at the interface. The NanoSIMS shows that the interface is also sharp in the distribution of ^{18}O and ^{16}O. The combined electron probe and NanoSIMS analyses indicate that both cation and isotopic exchange occurred during solution and re-precipitation of the feldspar.

Nano-scale ion imaging combined with HRTEM is a powerful technique for imaging mineral surfaces and interfaces, and tracking the uptake of radionuclides.

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Gold associated with Neoarchean alkaline intrusion, Lac Bachelor, Abitibi, Canada

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Recent alkaline intrusion-related gold deposits have been recognized worldwide (e.g. Cripple Creek, Ladolam). Similar Neoarchean deposits are now recognized in the Canadian Superior Province but their metallogeny is still misunderstood; the Lac Bachelor gold deposit is a key example. It is located within the Desmaraisville basin, a “Timiskaming-type” basin in the Abitibi Greenstone Belt Where it is hosted by a volcano-sedimentary assemblage, mafic and felsic intrusions, and associated with regional NE-SW oblique-slip faults.

Gold mineralization is located on the margin of the O’Brien stock, a polyphase alkaline quartz-syenite body which intrudes andesite and tuff. It displays porphyritic and equigranular textures. Injections of aplitic dykes occurred in late events. The O’Brien stock is mainly composed of Na- and K-feldspars, quartz, and mafic minerals. Purple fluorite is present, both disseminated in the syenite and in quartz-fluorite-pyrite veins that appears as comagmatic.

The Lac Bachelor gold deposit is characterized by several mineralized zones among which the Main zone (ZP) and the B zone (ZB) are the most economically important. A porphyry-style mineralization is present at the stock margin with quartz, quartz-magnetite, quart-fluorite, and pyrite stockwork. Subhorizontal quartz-fluorite veins extend into the host rocks proximal to the stock. The Main and B zones are mainly localized in tuffs at the edges of the pluton and follow pre-existing discontinuities. Gold occurs in association with disseminated pyrite, magnetite, haematite, and rare chalcopyrite and pyrrhotite. In the ZP and lesser in the ZB, the magnetite is oxidized into haematite. Gold is present in highly altered (haematite-carbonate) zones associated with disseminated pyrite. The ZB is less haematized than the ZP, which is consistent with the timing: structural relations between these zones suggest that the ZB was formed first and the ZP occurred after.

The hydrothermal event is clearly related to the intrusion of the O’Brien syenite. However, fluids appear to have followed pre-existing discontinuities that focused mineralization. Results illustrate the complementary roles of magmatic and structural controls during the mineralization processes.

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