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Tracing Gold using Lithium Isotopes

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Tremendous progress has been achieved over the last decades in understanding the behavior of Li and its isotopes in hypogene/supergene environments. Lithium is mobile in hydrothermal fluids but fixed during metasomatism. Lithium isotopes fractionate primarily during fluid-rock reaction, although kinetic isotopic fractionation also results from the rapid diffusivity of Li. Here, δ^7Li values of altered rocks from the Hemlo and Red Lake world-class orogenic Au deposits, Canada, are used to investigate the behavior of Au. At Hemlo, primary Au mineralization deposited prior to peak metamorphic conditions and was subsequently remobilized during prograde/retrograde metamorphic-hydrothermal alteration. Bulk rock [Li] and δ^7Li values are combined with mineral Li-Au concentrations to study the remobilization of Au during retrogradation and subsequent weathering. Results show that Au was remobilized from K-feldspar to biotite, chlorite, muscovite, and white mica during retrogradation, and that this was accompanied by increases in [Li] and decreases in δ^7Li values (Fig. 1). Although Li is present in the crystal structure of phyllosilicates, LA-ICP-MS patterns suggest that Au instead occurs as nano-inclusions, likely in the interlayer space of phyllosilicates, which is supported by similar ionic radii of K^+ (1.52 å) and Au^+ (1.51 å) in 6-fold coordination. Similar mineralogy, major/trace element- and Li isotopic compositions of surface and underground samples discount the possibility that remobilization was supergene. Lack of systematic variations in [Au], [Li], and δ^7Li values over a 7 km transect suggest that Au was remobilized only locally.

In order to further constrain the distance over which Au is remobilized, samples were collected at Red Lake over a ~20 m drill core interval. The δ^7Li values and [Au] intercorrelate (R^2=0.61) and increase gradually while approaching the ore zone, through the 20 m sequence of retrograde phyllosilicate recrystallization (Fig. 2). Laser ablation ICP-MS maps show Au in arsenopyrite in the ore, but homogeneously distributed in white mica outside the ore zone. Overall, these results show that Au is effectively remobilized over the decameter scale during retrograde metamorphic-hydrothermal alteration, and suggest that Au^+ is thus relocated within the interlayer space of phyllosilicates, possibly replacing K^+ in biotite, muscovite, and white micas.