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Identifying extremely low-concentration non-target components in copper ores and concentrates

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Mesoproterozoic copper ores in South Australia contain low to moderate concentrations of uranium, representing either a potential economic by-product, or an unwanted contaminant, depending on concentration. The daughter products of ^{238}U and ^{235}U decay, including the short half-life α-emitters, ^{210}Po and ^{210}Pb (hereafter ^{210}RN), will be present within the parent orebody at extremely low concentrations and in secular equilibrium. Fluid- and pore-driven migration over geological time, and the substantially different chemical behaviours of the daughter RN compared to U may, however mean that ^{210}RN do not occur in the same mineralogical site as parent uranium. This raises the possibility that they are decoupled from U during processing and can report preferentially to copper concentrate. Downstream, they may report preferentially to smelter dusts. Although certain 'common sense' predictions can be made on the basis of chemical data for Po and Pb, remarkably little reliable information is currently available on the mineralogical hosts for ^{210}RN in any solid media, thus making the search for ^{210}RN in complex, fine-grained ores or concentrates a major challenge. Information on the mineral host for ^{210}RN is, however, essential to guide attempts to eliminate or reduce unwanted ^{210}RN in copper concentrates. These are the overarching goals of the ARC Research Hub for Australian Copper-Uranium (http://www.adelaide.edu.au/copper-uranium-research/)

Concentrations of ^{210}RN are so low (fractions of one part-per-trillion) that their concentrations in individual minerals cannot be measured directly by conventional microanalytical methods. In order to understand their distribution in mill feed and concentrates, we thus rely on indirect information drawn from RN analyses of bulk material, comprehensive mineralogical characterisation underpinned by MLA or QEMSCAN data, and determination of the concentration of proxy elements and isotopes (notably ^{206}Pb) within specific minerals. Scanning electron microscopy is undertaken at highest magnification (i.e. visualisation of mineral grains well below 1 µm in size, acknowledging the possibility that ^{210}RN may exist largely as nanoparticles occurring at mineral-mineral boundaries). These data allow us to gain a qualitative understanding of Pb and U deportment within the ore and the different pathways responsible for changes of the deportment with time.

We are currently supplementing this information by the development of techniques designed to accurately track the location of α-emitters *in-situ* within a polished thin section. We will then use focussed ion beam – scanning electron microscopy (FIB-SEM) to extract ca. 10 x 30 µm-sized slices containing α-emitters and prepare these as thinned foils suitable for examination by high-resolution transmission electron microscopy, thus permitting visualisation of the smallest particles.

Preliminary data points to the significance of potential RN-hosts that include galena, typically <5 μm in size, and either associated with or independent of a U-bearing parent mineral (uraninite, coffinite and brannerite) as well as the selenide and telluride analogues of galena, clausthalite and altaite. Subordinate hosts may include barite and other sulphates, iron-oxides and –hydroxides, and a range of rare earth element bearing minerals, in which measurable U and Pb are noted.