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Technical Program

SS7: Uranium Ore Genesis and Exploration at Depth

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Ore fluids recorded in the compositions of magnesiofoitite and alumino-phosphate-sulfate (APS) minerals in the basement along the P2 structure and the McArthur River deposit, Athabasca Basin

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The P2 reverse fault is a reactivated structure in the southeastern Athabasca Basin that hosts the McArthur River uranium deposit, the largest high-grade unconformity-type uranium deposit yet discovered. This study is to document alteration below the unconformity, specifically within and near the P2 deformation zone and the basement-hosted Zone 2 ore body, in order to evaluate the role of the P2 fault as the conduit for basinal and basement fluids and identify fertile alteration. The results of this study show that the P2 structure is the site of multiple stages of diagenetic-hydrothermal alteration, which produced illite, sudoite, Fe-Mg chlorite, clinochlore, kaolinite, aluminum phosphate-sulfate minerals (APS) and tourmaline. Below the unconformity, the assemblage of illite plus sudoite is common in pelite and pegmatite regardless of proximity to the P2 fault, and kaolinite is distributed along the unconformity; however, the assemblage of magnesiofoitite (alkali-deficient Mg-tourmaline) plus LREE-rich APS has only been found in close proximity to the P2 structure.

Along the P2 fault, magnesiofoitite forms fine-grained (<0.2 mm) matrix, aggregates, overgrowths on metamorphic/magmatic dravite (< 2 mm), and veinlets (< 2 mm) that cross-cut sudoite and illite. APS form zoned pseudo-cubes (1 – 20 µm), disseminated and clustered within fine-grained matrix in altered metapelite and pegmatite and vary compositionally from LREE-rich, to Ca- or Sr-rich. Magnesiofoitite contains low contents of LREE ([LREE]N/[HREE]N) ≈ 0.2), yet significant amounts of U (0.2 – 3.7 ppm), Cr (2.9 - 110 ppm), V (65 – 260 ppm) and W (0.03 – 0.347 ppm). The low LREE in magnesiofoitite is consistent with its close proximity to LREE-rich APS, implying that the two minerals are contemporaneous. Some crystals of magnesiofoitite are essentially free of alkalis. Overall, low alkalis (<0.3 in apfu) and high U plus W in magnesiofoitite suggests that the fluids were acidic and oxidized in order to transport soluble complexes of U⁶⁺ and W⁶⁺. This fluid character is further supported by the co-precipitation of APS: significant Al solubility requires acidic fluids and the presence of SO₄²⁻ confirms the oxidized nature of the fluids.

The presence of these co-genetic minerals along the P2 structure suggests that the P2 fault was a conduit for uraniferous fluids; however, the fluids did not form uranium deposits all along the P2. The evidence further substantiates models in which the localization of large deposits required the focusing of an ascending reduced fluid to precipitate uraninite from the descending oxidized uraniferous fluid.