

Evidence for an Uraniferous Fluid in Alumino-Phosphate-Sulfate (APS) Minerals and Magnesiofoitite along the P2 Structure and the McArthur River Deposit, Athabasca Basin

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Abstract

The P2 reverse fault is a tectonically minor yet significant reactivated structure in the southeastern Athabasca Basin that hosts the Zone 2 ore body of the McArthur River uranium deposit, the largest high-grade unconformity-type uranium deposit yet discovered. The P2 structure is the site of multiple stages of diagenetic-hydrothermal alteration, which produced illite, sudoite, Fe-Mg chlorite, clinocllore, kaolinite, aluminum phosphate-sulphate minerals (APS) and tourmaline. In the basement, the assemblage of illite plus sudoite is common at many localities, and kaolinite is distributed along the unconformity and in basement quartzite, but the assemblage of magnesiofoitite (alkali-deficient Mg-tourmaline) plus LREE-bearing APS is only found in close proximity to the P2 structure.

The crystallization of magnesiofoitite was late rimming earlier formed tourmaline: dravite (Mg- tourmaline < 2 mm) and schorl (Fe-tourmaline, < 2 mm). It is fine-grained (<0.2 mm) and occurs as aggregates, dissemination in the matrix and veinlets (< 2 mm) with partially dissolved quartz. APS minerals form pseudocubes (1 – 20 µm) disseminated and clustered in fine-grained matrix. Back-scattered electron images show zoning due to variations in concentrations of Ca, Sr, and LREE. Magnesiofoitite shows low LREE ($[LREE]_N/[HREE]_N \approx 0.2$), 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 abundance of LREE in magnesiofoitite is consistent with its close proximity to APS minerals that contains high LREE, implying that the two minerals are complementary and co-genetic. Some grains of magnesiofoitite are essentially free of alkalis. The low contents of alkalis (<0.3 in apfu) and high U and W suggest that the fluids were uraniferous, acidic and oxidized to transport soluble UO_2^{2+} and WO_4^{2-} complexes. The fluid character is further supported by the composition of APS, as Al solubility requires acidic fluids and the presence of SO_4^{2-} confirms oxidized condition of the fluids. The presence of these co-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 suggests that localization of large deposits required the focusing of an ascending reduced fluid to interact with the descending oxidized uraniferous fluid in order to precipitate uraninite.

