Fluid evolution recorded in the composition of tourmaline and aluminum sulfate-phosphate minerals along the P2 fault and McArthur River uranium deposit, Saskatchewan

E. E. Adlakha[1], K. Hattori[1], G. Zaluski[2], T. Kotzer[2], and E.G. Potter[3]

[1]Department of Earth Science, University of Ottawa, Ottawa, Ontario, Canada, K1N 6N5 (*correspondance: eadla028@uottawa.ca; keiko.hattori@uottawa.ca)
[2] Cameco Corporation, Exploration Office, Saskatoon, SK. Canada, S7M 1J3 (gerard_zaluski@cameco.com; tom_kotzer@cameco.com)
[3]Geological Survey of Canada, Ottawa, Ontario, Canada, K1A 0E8 (eric.potter@nrcan-rncan.gc.ca)

The P2 fault is a 13 km long, reverse displacement basement structure rooted in graphitic metapelite in the eastern Athabasca Basin and hosts the world-class McArthur River uranium deposit. An assemblage of magnesiofoitite (alkali-deficient tourmaline) and LREE-rich aluminum sulfate-phosphate minerals (APS) occur along the entire P2 fault. These minerals are found in highest abundance in proximity to the McArthur River deposit. In the basement, magnesiofoitite was found only along the P2 fault. Magnesiofoitite forms aggregates of fine-grained (typically < 0.2 mm) needles that are intergrown with sudoite and/or illite, or form veinlets (< 2 mm). Magnesiofoitite is similar in composition along the entire P2 fault, independent of mineralization, and contains a high vacancy in its alkali site (0.70 – 0.85 apfu), suggesting low Na+/H+ in the fluids. Proximal to mineralization, magnesiofoitite is slightly enriched in HREE relative to LREE ($[LREE]_N/[HREE]_N \approx 0.7$), and displays slightly greater variability in LREE distal to mineralization. APS occur within and outside the P2 fault, but the compositions vary depending on the locations. Along the fault, APS form zoned pseudo-cubes (> 20 µm), with Sr- Ca- and SO_4^{2-}-rich cores (svanbergite composition) and LREE- and P-rich rims (florencite composition). These APS contain up to 16 ppm U, suggesting that the fluids were uraniferous. Outside the fault, APS occur along the unconformity with kaolinite and are svanbergitic in composition. Magnesiofoitite and florencite show complementary REE patterns implying that the two minerals are contemporaneous. APS cores contain high SO_4^{2-}, suggesting an earlier oxidized fluid, whereas SO_4^{2-}-poor rims, especially near the ore, indicate that the fluid became relatively reduced. Reducing conditions are further supported by the presence of sulfides associated with florencite. The data suggests that the uraniferous fluids passed along the entire P2 fault, but the mineralization took place only when the fluids were reduced.