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Compositional variation and timing of aluminum phosphate-sulfate minerals in the basement rocks along the P2 fault and in association with the McArthur River uranium deposit, Athabasca Basin, Saskatchewan, Canada†

Erin E. Adlakha[1,*] and Keiko Hattori[1]

[1]Department of Earth Sciences, University of Ottawa, Ottawa, Ontario, K1N 6N5, Canada

Abstract

The Athabasca Basin hosts world class uranium deposits, such as the McArthur River deposit. This paper presents the occurrence of aluminum phosphate-sulfate (APS) minerals in the metasedimentary rocks along the P2 fault, the main ore-hosting fault of the McArthur River deposit. It compares the APS minerals along the P2 fault with those outside the fault, examined in this study, and those from other deposits of the Athabasca Basin and from other Paleo- to Mesoproterozoic basins worldwide.

APS minerals are common along the P2 fault but rare outside of the P2 fault zone in the basement and along the unconformity between the Athabasca sandstones and the basement. The APS minerals along the P2 fault occur with sudoite (± illite, magnesiofoitite) and are zoned with Sr-, Ca-, and S-rich cores (solid solution between svanbergite, crandallite, and goyazite) and LREE- and P-rich rims (close to florencite composition). APS minerals in the Bleached Zone (altered rocks along the unconformity consisting predominantly of kaolin and illite) are Sr-, Ca-, and S-rich (high svanbergite component) and occur with kaolin. APS minerals in the Red-Green Zone (mingled red hematitic and green chloritic basement rocks below the Bleached Zone) occur with sudoite and clinochlore. They contain relict cores of LREE- and As-rich arsenoflorencite-(Ce) and rims of svanbergite-goyazite-crandallite solid solution.

The occurrence of svanbergite-crandallite-goyazite along the unconformity suggests their formation by relatively oxidizing fluids during diagenesis of the overlying sandstones. The relict cores of arsenoflorencite-(Ce) in the Red-Green Zone are interpreted to be the product of paleo-weathering before the deposition of the Athabasca sandstones. Florencitic APS minerals are found along the entire studied strike length (7 km) of the P2 fault, including the ore zone and non-mineralized areas, but are absent outside the fault zone. The florencitic APS minerals contain low SO_4^{2-} in the ore zone, suggesting relatively reducing conditions during their crystallization. Zoned APS minerals (with svanbergitic cores and florencitic rims) proximal to ore contain elevated U (up to 16 ppm). These features suggest that diagenetic, oxidizing, and uranium-bearing fluids traveled along the P2 fault and became relatively reduced, especially within the ore zone. It also suggests florencitic APS minerals are contemporaneous with uranium mineralization. The restricted occurrence of florencitic APS mineral along the P2 fault in the basement suggests their use in identifying fertile basement structures associated with uranium mineralization.

Keywords: Hydrothermal alteration, APS, uranium mineralization, florencite, svanbergite, arsenoflorencite, diagenesis, paleo-weathering, unconformity-type uranium deposits