Chlorite Alteration of Pre-Ore Pyrite at McArthur River Uranium Mine, Athabasca Basin: Possible Implications to Ore Deposition

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Introduction

The McArthur River uranium mine in the Athabasca Basin, Canada, hosts the largest high-grade uranium deposit in the world, accounting for 12% of global uranium production in 2015. McArthur River is a Proterozoic unconformity-related uranium deposit, with ore bodies located in the P2 fault zone at the unconformity between conglomerate and metamorphic basement rock, and up to 120 m below the unconformity in basement rock. Oxidized basinal brines are considered the most likely medium for transporting dissolved UO_2^{2+} to the unconformity [1]. The reductant responsible for precipitating UO_2 from solution is unknown [2], but there is a clear spatial association between uranium reduction and the P2 reverse fault.

Discussion of Results

Core logging and sample collection were conducted during the 2015 field season. All samples are referenced to the core logs. Petrography and SEM investigations were used to establish the paragenesis and alteration styles in altered basement rocks. FE-SEM, EMP, and XRD investigations have established the presence of di-trioctahedral sudoite in metamorphic basement samples from the P2 fault zone near the unconformity.

Here, a new model for the reduction of uranium at McArthur River is proposed. Field observations indicate that the P2 reverse fault is characterized by the abundant presence of fault-hosted pre-ore pyrite veins. The formation of pyrite veins resulted in the illitization of feldspar in the basement rocks. Oxidizing Na-Mg-Ca chloride basinal brine, forming abundant secondary fluid inclusions, penetrated into the basement along the P2 fault and oxidized the pre-ore pyrite veins, resulting in the reduction of the brine. Pyrite veins and illite were replaced by Fe^{3+}-bearing sudoite and fluorapatite. Reduced basinal brine buffered by the presence of pre-ore pyrite along the P2 fault was responsible for the reduction of UO_2^{2+} and the formation of world-class unconformity-related deposits such as McArthur River.

[1] Hoeve and Sibbald (1978) *Econ. Geol.* **73**, 1450-1473 . [2] Mercadier et al. (2010) *Lithos* **115**, 121-136.