Temporally Constraining Fluid Flow in Basement Shear Zones of the Athabasca Basin using Re-Os Sulfide Geochronology

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The Athabasca Basin of Western Canada is host to one of the largest uranium endowments in the world with total uranium production exceeding 20% of the global market [1]. This is in effect the result of large-scale physio-chemical processes concentrating 100 times more uranium than bulk continental crustal levels over relatively narrow, albeit uncertain, temporal scales [2, 3].

Current models for U mineralization invoke basin-wide oxidizing uranium-rich fluids infiltrated Athabasca Basin sediment cover until a redox barrier – such as reducing fluids derived from reactivated basement shear zones (BSZ) – induced uranium precipitation ca. 1.6-1.4 billion years ago [3, 4]. Athabasca BSZ, which are structurally associated with graphitic ± pyritic assemblages, likely predate uranium mineralization by several hundred million years (5). Yet, despite playing an integral part in the genesis of the Athbasca uranium deposits, the formation and fluid-flow histories of these deep-seated faults have yet to be critically examined.

Here we present preliminary Re-Os pyrite geochronological evidence delimiting the timing of fluid flow from the Maybelle River Shear Zone on the westerly flanks of the Athabasca Basin of Alberta, Canada. Our Re-Os ages document the timing of pyrite formation to ca. 1.9 Ga, late in the Taltson orogeny, which predates peak uranium mineralization by 200-300 Ma [5]. Temporally correlating these two events provides a mechanistic answer to the formation of this, and similar, structural conduits associated with world-class uranium deposits, such as those found in the Athabasca Basin. More broadly, our preliminary findings provide a novel way for tracking the timing of fluid flow in graphitic shear zones.

[1] World Uranium Mining Production (2019), [2] Rudnick et al. (2014) Treastise on Geochemsitry, [3] Jefferson et al. (2007) Geological Survey of Canada, Bulletin 588, p. 23-67, [4] Chi et al. (2019), Nature, v. 9, p. 5530, [5] Card et al. (2007), Geolgoical Survey of Canada, Bulletin 588, p. 69-78.