Structural analysis and preliminary alteration-mineral paragenesis of the Arrow uranium deposit, Athabasca basin, Saskatchewan

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The Athabasca basin, in northern Saskatchewan, hosts the world's highest-grade uranium deposits. These deposits are commonly spatially associated with ductile shear zones in the crystalline basement rock that have undergone multiple episodes of brittle reactivation. Although the evolution of these structural zones is complex, unraveling the relationship between structure, alteration, and mineralization through time is vital to understanding the controls on uranium mineralization. This study examines the relationship between the ductile shear zones and their brittle reactivation, mineral paragenesis, and uranium mineralization at the Arrow deposit, the largest, undeveloped high-grade uranium resource in the Athabasca basin. Approximately 400 samples of unaltered, altered, and mineralized rocks have been collected from 18 representative drill holes that intersect the deposit and a combination of hand sample examination, thin-section microscopy, and electron microprobe analysis has been used to generate a detailed paragenesis of the Arrow deposit. Paragenetic information has been integrated with the structural analysis of over 18,000 measurements of foliation, fractures, veins, shears, mylonites, breccias, cataclasites, and fault gouges, as well as plunge and trend of linear structures including slickenslides and ductile lineations. The structural system at the Arrow deposit is a strike-slip dominated fault system with complex Riedel shear fracture geometry. The Arrow fault system originally developed along ductile, sub-vertically dipping, northeast-southwest trending chlorite-graphite-bearing phyllonites (the A1, A2, A3, A4 and A5 shears) along the limb of a possible regional-scale fold. Detailed analysis of the major structural trends in three dimensions suggests that primary R-, R'-, P-, and P'-shear fractures formed during multiple episodes of predominantly sinistral brittle reactivation of the pre-existing ductile structures allowing for the migration of hydrothermal fluids, alteration of host rocks, and precipitation of uranium mineralization. The relative timing and spatial association of structural events/reactivations, alteration and mineralization determined in this study will provide the framework for the on-going dating of the mineralizing events. Overall, the Arrow deposit is a structurally-controlled uranium deposit entirely hosted within competent basement rocks below a thin-veneer of Athabasca Group sandstones. The continued study of the structural controls on mineralization present at the Arrow deposit will aid in developing a structural template for exploration of new target areas within the recently established southwestern Athabasca basin uranium camp.