New Ideas about the Relation between Fluids and Uranium and Gold Mineralization in Saskatchewan

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ABSTRACT

Fluids are critical components in both the formation and the preservation of many ore deposits. As a consequence, characterizing the origin, composition, evolution, and timing of fluids in the environs of ore deposits should be a prerequisite for formulating effective genetic and exploration models.

The Athabasca Basin in Saskatchewan hosts several significant unconformity-type uranium deposits that formed from specific fluids (namely, evolved basinal brines and reduced basement fluids) at specific times (namely 1400 Ma and 900 Ma) in the geologic evolution of the basin. Isotopic, geochemical, fluid inclusion, and geologic data indicate that these deposits formed from the interaction of oxidized, uraniferous basinal brines with either reduced basement lithologies or with reducing, Ni-Co-As-Fe fluids that issued from the basement. Simple-type deposits, in which metals other than uranium are only sparsely abundant, form from the former process; whereas, complex-type deposits, which contain Co-Ni arsensides, form from mixing between basinal and geochemically-diverse basement fluids. Iron is the major reductant in both processes, and graphite plays a structural, rather than geochemical, role. The high rare-earth element (REE) contents of unconformity-type deposits and the general lack of detrital zircon and apatite in the basin indicate that the major source of uranium and REEs in the deposits is most likely from alteration of detrital zircons and fluorapatites which released the REEs as fluoride complexes, although variable amounts of REEs, as well as occasional Au and PGEs, were in the basement fluids. The same structures that served to focus fluid-basement interactions have also served as conduits for much later fluid events involving low-temperature, meteoric waters that variably remobilized previous high-grade uranium mineralization. Characterizing potential areas where mineralizing fluids or extensive later fluid events have occurred not only is an indication of the prospectivity, but also can be used to model the environmental effects of fluids on uranium mining in general.

Lode-gold deposits in Saskatchewan have also formed from specific fluids at specific times, but later fluid events may have had a more significant effect on their grade and character. Ar-Ar ages from muscovite, biotite, or hornblende parageneticaly associated with the gold in several deposits are identical to ages from these minerals far from any Au mineralization, indicating that the structures that host the deposit are relatively old, whereas the gold in its present setting is younger, most likely remobilized from previous gold mineralization. The stable isotopic and chemical compositions of minerals parageneticaly equivalent to the gold are consistent with derivation of the deposits in their present form from "metamorphic" fluids, which are really surficial fluids, buried to significant depths, and subsequently released during dehydration reactions. In some areas, those quartz veins that host gold mineralization have distinct chemical and isotopic compositions, which can be used to guide exploration, provided geologic and tectonic data are also integrated.