

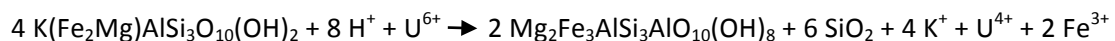
Unconventional Redox Controls on Uranium Deposits in Wyoming Tertiary Basins

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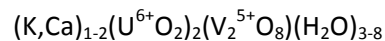
In classic models, the formation of roll-front uranium deposits is critically dependent upon the presence of materials capable of causing hexavalent uranium to be reduced to tetravalent uranium and precipitated from the migrating ground water. Long-recognized reductants (buried organic material and pyrite) are common in many Wyoming roll-front deposits, but some deposits formed in the absence of any obvious reductant phase, and a few deposits are made up primarily of oxidized uranium phases. These unconventional deposits are the focus of this report.

Roll front deposits in the northern Great Divide Basin lack obvious reductants such as pyrite and significant organic material, but maintain classic roll-front geometry indicating that the deposit was formed in response to progressive oxidation of a reductant phase in the original sedimentary rocks. X-ray diffraction studies reveal an abrupt appearance of a chlorite phase at the expense of detrital biotite that correlates spatially with the position of the ore mineralization. A corresponding increase in abundance of ferri-hydroxide, decrease in K₂O concentration in the whole rock bulk composition, and appearance of a chlorite phase enriched in Mg/(Mg+Fe) relative to the original biotite suggest the following reaction for generation of those deposits:



The details of the stoichiometry depend on the composition of the original detrital biotite. In the presence of low pH fluids, iron-rich biotite reacts with hexavalent uranium to produce less iron rich chlorite, quartz, and tetravalent uranium. Potassium is lost from the system, and ferri-hydroxides appear. The reaction predicts a jump in pH for ambient fluids on the down-gradient side of the deposit; this change is independently confirmed by sulfur isotope studies in this deposit (Hough et al, in review).

Some uranium deposits in Tertiary basins in Wyoming area made up primarily of strongly oxidized uranium phases. Powder River Basin deposits are locally strongly enriched in carnotite group minerals, even where those deposits occur well below the modern water table. These vanadium-rich domains also include iron vanadates and vanadium oxide minerals, and obvious reductant phases such as pyrite and organic materials are absent from these areas of the deposits. These vanadate phases occur as cements and are texturally consistent with primary deposition as opposed to origin through oxidation of primary tetravalent uranium minerals. Both uranium and vanadium in carnotite-group minerals occur in highly oxidized state:



The geometry of these vanadium-rich domains is poorly understood, as is the source of the vanadium necessary for their development. Their presence complicates ISR mining because (a) they are not amenable to extractions with oxidizing lixiviants and (b) the abundant vanadium associated with them complicates economic processing of these ores. We are presently conducting a detailed study of a region of high concentrations of carnotite-group minerals from the Powder River Basin and plan to report on the progress of this study during this meeting.