Systematic investigation of the product of microbial U(VI) reduction by various microorganisms.

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Bioremediation of uranium contaminated groundwater is based on the microbial *in-situ* reduction of soluble, and hence mobile, oxidized uranium, U(VI), to a comparatively insoluble reduced species, U(IV). A number of microorganisms have been identified as capable of reducing uranium, including metal-reducing bacteria (MRB) and sulfate-reducing bacteria (SRB). While the product of microbial U(VI) reduction is often reported as the mineral uraninite, UO_2, there is increasing evidence that, in some cases other compounds may be produced. In this study, we evaluated the product of U(VI) reduction by six microorganisms under near-identical chemical conditions to determine the variability in the speciation of the reduced uranium product.

The microorganisms considered included SRB and MRB, Gram negative and Gram positive bacteria known to carry out U(VI) reduction: *Shewanella oneidensis* MR-1, *Desulfovibrio vulgaris*, *Shewanella putrefaciens* CN32, *Geobacter sulfurreducens*, *Geobacter metallireducens* and *Desulfotomaculum reducens* MI-1. The products were characterized by XAS (X-ray Absorption Structure). The majority of the microorganisms produced a reduced mineral structurally homologous to stoichiometric UO_2. However, in three cases, the product was a reduced uranium species lacking the U second-shell structure that is typical of UO_2. Those products were determined to be sorbed species of reduced uranium that formed in conjunction with reduced iron precipitates (*Geobacter spp.*) or bacterial spores (*D. reducens*). Thus, we hypothesize that the chemical reduction of U(VI) by a reduced Fe-phase or biological reduction by spores leads to the formation of sorbed U(IV) whereas direct enzymatic reduction of U(VI) produces UO_2.

In order to confirm that the above conclusion holds in the field after a remediation effort, columns packed with sediment from a uranium contaminated site and seeded with *Shewanella oneidensis* MR-1 were reacted with influent containing an electron donor and U(VI). The reduction of added U(VI) and endogenous Fe(III) was observed over the following three months and the uranium product characterized using XAS.