Influences of organic matter on U retention and mobilization in contaminated aquifers

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Uranium (U) contamination occurs at legacy ore-processing sites located throughout the Western United States. U groundwater concentrations remain elevated at many sites, indicating that there is a source of stored U that can be mobilized into the groundwater. We sought to gain insight into how tetravalent U (U(IV)) stored within anoxic sediments could be cycled between sediment and groundwater. We therefore investigated (1) how U becomes incorporated into anoxic sediments, and (2) how it could be mobilized back into the groundwater.

Investigation of U(IV) speciation and distribution in model batch reactors using a combination of X-ray absorption spectroscopy and nano-scale imaging techniques (nano secondary ion mass spectrometry and scanning transmission X-ray microscopy) revealed that U was primarily adsorbed to organic matter at field-relevant U concentrations. We therefore developed a conceptual model in which U(VI) was reduced within hot-spots of organic matter, reactive mineral species, and microbes; and subsequently adsorbed to these materials. Finally, we investigated whether U(IV) could be oxidatively mobilized in diffusion-limited flow-through reactors, finding that the efficiency of oxidative mobilization will depend on the content and quality of organic matter present in aquifer sediments, as well as the rate of oxidant supply. Other mechanisms, such as colloidal mobilization, should also be considered.

Our results suggest that organic matter has an important role to play in U immobilization at contaminated sites as both a sorbent and as an electron donor.