Uranium Remediation at an *in situ* Recovery(ISR) site: Isotope Ratios as Indicators of Reducing Enviroments

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Natural attenuation of highly soluble and toxic U(VI) to insoluble U(IV) at ISR mining sites is a desired post-mining remediation strategy. Detection of naturally occurring reducing environments and assessment of the reductive capacity of subsurface sediments are extremely important for successful remediation via natural attenuation of U(VI). Reduction of soluble U(VI) or Se(VI) within or downgradient of ISR-mined ore bodies induces measurable isotopic fractionation. Isotopically fractionated U, Se or S in groundwater should thus indicate reducing environments. Here, we use multiple isotopic systems (U, Se, S) to detect reducing conditions conducive to natural attenuation of U(VI) at an ISR mining site at Rosita, TX, USA. We measured $\delta^{238}U$, ($^{234}U/^{238}U$), $\delta^{82}Se$, $\delta^{34}SO_4$, $^{87}Sr/^{86}Sr$ in groundwater collected from 33 wells located within, upgradient and downgradient of the roll-front type U ore body. The $\delta^{238}U$ of groundwater samples varied from 0.56‰ to -1.96‰. The $\delta^{82}Se$ values ranged from -1.44‰ to 6.14‰. The highly fractionated U and Se isotope ratios in the ore-body and in downgradient monitoring wells suggest U(VI) and Se(VI) reduction, and post-mining recovery of natural reducing conditions in the ore zone. The characteristic low ($^{234}U/^{238}U$) of ~0.8 of the ore-zone groundwater can serve as a tracer for the movement of ore-zone U. Future work includes isotopic characterization of the U ore and experimental determination of the U(VI) reducing capacity of and associated U isotopic fractionation in the downgradient reduced sediments.