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Chromium Stable Isotope Fractionation During Bacterial  
Reduction of Hexavalent Chromium

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Chromium is a common contaminant in surface water and ground water. It is redox-active, occurring as Cr(VI), which is soluble and toxic, and Cr(III), which is insoluble and less toxic. Reduction of Cr(VI) to Cr(III) is often the most important reaction controlling attenuation of Cr plumes, and Cr stable isotope ( $^{53}\text{Cr}/^{52}\text{Cr}$ ) measurements show great promise as indicators of this reaction. Previous results indicate Cr(VI) reduction involves a kinetic isotope effect; lighter isotopes reduce at greater rates and heavier isotopes become increasingly enriched in the remaining Cr(VI) with increasing extent of reduction. If the size of this effect can be constrained well, then precise estimates of reduction are possible. The few experiments completed to date involved abiotic Cr(VI) reduction and indicated a fractionation factor of  $1000\ln\alpha = 3.4 \pm 0.2$ . Abiotic reduction by Fe(II), organic compounds, and other agents is possible in natural settings, but some bacteria are known to reduce Cr(VI) as well. This study determined Cr fractionation factors for anaerobic reduction by *Shewanella Oneidensis* MR-1. Previous studies of kinetic isotope effects during reduction of sulfate, selenate, and nitrate reveal that fractionation factors depend on the metabolic states of the bacteria. Those in rich media usually induce less fractionation than those in leaner conditions. Concentrations of electron donors and other nutrients are usually small in natural settings, so we suspended MR-1 cells in buffer solutions with small concentrations of lactate or formate, and Cr(VI). Reduction occurred slowly, over days or weeks. The calculated value of  $1000\ln\alpha$  was  $4.1 \pm 0.2$  for several experiments with a range of donor concentrations between 3.6 and 100 micromolar. This



suggests that under the lean conditions found in most aquifers, the kinetic isotope effect induced by bacterial reduction is roughly equal to that induced by abiotic reduction, and that the Cr isotope method will be useful for estimating Cr(VI) reduction regardless of the exact mechanism involved.

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