Evaluating the extent of Cr(VI) reduction in polluted groundwater: Toward better δ53Cr fingerprinting of sources

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Carcinogenic hexavalent chromium [Cr(VI)] in groundwater may result from geogenic and athropogenic sources. Geogenic sources of Cr(VI) are dominated by weathering of ultramafic rocks. Anthropogenic sources include leakage of technological solutions from various industrial operations. At some sites, spontaneous reduction of dissolved Cr(VI) to insoluble, non-toxic Cr(III) has been observed. Precipitation of Cr(III) is associated with a Cr isotope fractionation. The residual Cr(VI) becomes enriched in the heavier isotope 53Cr. The δ53Cr values of the pollution sources must be known if we want to evaluate the extent of Cr(VI) reduction. Such calculations, using a Rayleigh model, can be done especially for closed systems. We will present the results of two Cr isotope fingerprinting studies of potential pollution sources in the Czech Republic.

We determined δ53Cr values of solutions generated during Cr electroplating, chromating and anodizing at nine industrial sites. The source chemical, water-soluble chromium trioxide (CrO3) had a δ53Cr value of 0.0 ‰, nearly identical to the Earth's mantle and chromite deposits. A small-to-negligible Cr isotope fractionation was observed between the plating baths and the source chemical. Across all plating bath samples (n = 30), the mean δ53Cr value was 0.2 ‰. Chromium in rinsewaters was isotopically slightly heavier (0.4 ‰). The mean δ53Cr value of contaminated groundwater in the same region was significantly higher (2.9 ‰), indicating natural attenuation of the groundwaters by Cr(VI) reduction. We suggest that, at industrially contaminated sites, aquifer δ53Cr(VI) values higher than 1.0 ‰ are a result of Cr(VI) reduction.

We also determined δ53Cr values along a 70 m deep profile in serpentinites at Biskoupky, and in four serpentinite quarries near Kutna Hora. These geogenic sources of Cr pollution had a much wider range of δ53Cr values (-0.4 to +1.2 ‰; n = 62) that the above industrial sources. In the presentation, we will discuss implications of this data set for δ53Cr tracing of geogenic Cr cycling in the environment.