Geochemical behavior of uranium in mine tailings at Freital, Germany: a µ-XRF, µ-XAFS and µ-XRD study

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Risk assessments of soils and sediments contaminated by uranium require detailed knowledge of actinide speciation and its evolution over time. We therefore studied a former Saxonian mine tailings, which had been covered but else left undisturbed, after a period of 30 years using Synchrotron-based microfocus-techniques (µ-SXRF, µ XAFS, µ-SXRD with micrometer and nanometer resolution), bulk EXAFS spectroscopy, and chemical extractions.

At smaller depth, hydrochloric acid from the ore extraction procedure was completely neutralized by an infiltration front from the construction waste used as cover material, resulting in precipitation of jarosite and gypsum. Even 30 years after the ore extraction, uranium remains soluble as U(VI) sorption complexes associated with muscovite, illite and kaolinite. At greater depth, the low pH from ore extraction was conserved. U(VI) sorption complexes constitute only a minor fraction, while most uranium is hosted by U(IV) and U(VI) containing minerals like coffinite, uraninite, uranyl hydroxide, and vanuralite. The U(IV) minerals are recalcitrant during chemical extractions, suggesting low uranium solubility even at oxic redox conditions.

The results demonstrate a very high variability of uranium speciation and hence potential mobility, which depends on geochemical parameters and site history. Currently the nanoscale spatial variability of sulfur oxidation state is investigated by S K-edge µ-XANES, and bulk XAFS spectroscopy at several metal edges is performed to gain further insight into the history of redox conditions and to link the uranium geochemistry to that of arsenic, copper, zinc and other associated metals.