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Microscopic and spectroscopic insights into uranium(VI) association-reduction processes by a sulfate-reducing microorganism

MR. STEPHAN HILPMANN[1], ROBIN STEUDTNER[1], ANDRÉ ROSSBERG[2,3], RENÉ HÜBNER[4], DAMIEN PRIEUR[1,5], STEPHEN BAUTERS[1,5], KRISTINA KVASHNINA[1,5], THORSTEN STUMPF[1] AND ANDREA CHERKOUK[1]

[1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Resource Ecology

[2]European Synchrotron Radiation Facility (ESRF)

[3]Helmholtz-Zentrum Dresden-Rossendorf e.V. (HZDR)

[4]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research

[5]Rossendorf Beamline (BM20-ROBL), European Synchrotron Radiation Facility

Presenting Author: s.hilpmann@hzdr.de

Clay rock represents a suitable host rock for the long-term storage of high-level radioactive waste with bentonite as backfill material. In the event of a worst-case scenario, water can enter the repository. It is possible that naturally occurring microorganisms can interact with the radionuclides and thereby change the chemical speciation or induce redox reactions.

Among different sulfate-reducing bacteria, *Desulfosporosinus* species represent important members of the microbial communities in both clay rock and bentonite.[1,2] *Desulfosporosinus hippei* DSM 8344^T is a close phylogenetic relative to an isolated bacterium from bentonite.[3] Therefore, this strain was selected to get a more profound insight into the uranium(VI) interactions with naturally occurring microorganisms from deep geological layers.

Time-dependent experiments in artificial Opalinus Clay pore water[4] (100 µM uranium(VI), pH 5,5) showed a high removal of uranium from the supernatants within a short time range. UV/Vis studies of the dissolved cell pellets provided clear proof of a partial reduction of uranium(VI) to uranium(IV) in the samples, although bands of uranium(VI) were still observable. These findings propose a combined association-reduction process as an explanation for the ongoing interaction mechanism.

Uranium aggregates formed on the cell surface were visible in TEM images. Furthermore, cells released membrane vesicles as a possible defense mechanism against cell encrustation.

In addition, HERFD-XANES measurements confirmed the reduction of uranium(VI). But with these measurements also the presence of uranium(V) in the cell pellets could be demonstrated. This provides first evidence of the involvement of uranium(V) in uranium(VI) reduction by sulfate-reducing microorganisms. With the help of EXAFS measurements, different cell-related uranium species were detected.

This study helps to better understand the complexity of redox processes in the environment and contribute to a safety concept for a nuclear repository in clay rock. Moreover, new insights into the uranium(VI) reduction mechanisms of sulfate-reducing bacteria were presented.

References:

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