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Ruprechtov natural analogue site: summary of the real system behaviour

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Deep geological repositories (DGR) for the final disposal of spent nuclear fuel and high-level radioactive waste are primarily based on a multi-barrier concepts, consisting of a host rock as a natural geological barrier and an engineered barrier-system. Detailed investigations of suitable geological analogues may lead to a better understanding of the complex interrelations between transport and sorption of radionuclides in multi-barrier systems under natural conditions and especially on very long-term scales relevant for performance assessment.
The Ruprechtov site (W Bohemia) was chosen as a natural analogue because the geological and geochemical conditions are similar to sedimentary sequences which in many cases cover the potential host rocks for DGR. The site selection supported also natural accumulations of U, which enabled to identify the main mobilisation/immobilisation processes. During the international research, which took place at Ruprechtov site since 1995, multidisciplinary investigations were performed, including detailed hydrogeological, geological, mineralogical and geochemical characterisation. Furthermore, the core part of the investigations were focused on natural U occurrences as analogue for U migration and immobilisation in the DGR post-operational phase.
The Ruprechtov site represents a Tertiary basin with argillized volcano-detritic sediments, underlain by kaolin and granite. U-enrichments mainly occur in distinct layers of limited thickness on top of the kaolin close to the clay-lignite seams (Noseck et al., 2004). The combination of different analytical methods was applied to gain an insight into the behaviour of U in a complex natural system such as wet chemistry (distribution of U(IV) and U(VI), sequential extraction, 234U/238U-activity ratios determination) and various spectroscopic methods (SEM–EDX spectroscopy, synchrotron-based l-EXAFS, EMPA and confocal l-XRF). Noseck et al. (2008) presented the scenario for U enrichment: Microbial activity in the clay/lignite horizon led to the reduction of dissolved sulphate by sulphate-reducing bacteria, thereby leading to the formation of pyrite nodules. Noseck et al. (2008) also identified using determination of 234U/238U activity ratios that the accumulation process has to be at least older than 1 Ma year. In this period, CO2-rich water likely initiated U release from accessory minerals in the granite by formation of soluble uranyl-carbonate complexes. Uranium was transported into the clay/lignite horizon and accumulated there by reduction of U(VI) to U(IV) by thin As-pyrite layers on pyrite nodules formed by microbial sulphate reduction. Moreover, microbial degradation of organic matter in the clay/lignite horizon probably caused also phosphate release into the groundwater. The increased phosphate concentrations caused the precipitation of U as secondary phosphate minerals (e.g. ningyoite).
The key processes involved in U immobilisation in the argillaceous layers have been identified and can be used to reconstruct the geological history at the site. The gained results were summarized in several publications (e.g. Noseck et al., 2008, 2009, 2012).

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