Influence of colloids on uranium transport in nuclear waste repositories and abandoned uranium mines – a critical comparison

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It is widely recognized that colloids can influence the migration of toxic and radiotoxic elements such as uranium. There are transport-facilitating and transport-impeding effects caused by colloids.

The most common scenario assumed in performance assessment for nuclear waste repositories is contaminant transport through anoxic aquifers. Only transport-facilitating effects of colloids are usually taken into consideration for this case. For abandoned uranium mines, retarding influences of colloids, apart from mobilizing ones, are also of high interest since they have the potential of causing "natural attenuation" of the environmental hazard.

The formation of colloids containing U(IV) and U(VI) was studied by laboratory experiments and by comparing the results with field experience. It is shown that there may be transport-stimulating effects of colloids on the "immobile" contaminant U(IV) and transport-impeding effects on the "mobile" contaminant U(VI).

A key factor in assessing the impact of colloids in a geochemical setting is the timescale that needs to be taken into account. Very long periods of time must be considered for nuclear waste repositories. Here, the point in time at which a certain colloid-borne contaminant such as uranium reaches the biosphere depends on the moment at which spent fuel container leakage begins, the water flow velocity, the concentration and mobility of potential carrier colloids, the hindrance of colloidal transport by barrier materials, and the persistence (reversibility vs. irreversibility) of the binding of the contaminant onto the colloids. In the case of mines, the phase critical for the environment occurs when the flood water reaches the level where first connections to unprotected surface waters or underground drinking water resources occur. This phase is characterized by the „first flush" of the mine; the maximum release rate of contaminants such as U from the mine to the environment can be reduced by colloids via the flattening of the release rate profile. Whereas the timescale of critical contaminant release is in the range of centuries for the nuclear waste repositories, it lies in the range of only few years for abandoned uranium mines.

It is primarily the different dynamics of the processes behind these two different timescales that causes the different role of colloids for uranium migration in nuclear waste repositories and in abandoned uranium mines.