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Colloid/Nanoparticle mobility determining processes investigated by laser- and synchrotron based techniques

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Transport of pollutants can occur in the aqueous phase or for strongly sorbing pollutants associated on mobile solid phases spanning the range from a couple of nanometers up to approx. $\sim 1\mu$m; usually called colloids or nanoparticles [1,2]. A new form of pollutants are engineered nanoparticles (ENP's), where properties differ substantially from those of bulk materials of the same composition and cannot be scaled by simple surface area corrections. Potential harmful interactions with biological systems and the environment are a new field of research [3]. A challenge with respect to understand and predict the contaminant mobility is the contaminant speciation, the aquifer surface interaction and the mobility of nanoparticles. Especially for colloid/nanoparticle associated contaminant transport the metal sorption reversibility is a key element for long-term mobility prediction. The spatial resolution needed is clearly demanding for nanoscopic techniques benefiting from the new technical developments in the laser and synchrotron community [4]. Furthermore, high energy resolution is needed to either resolve different chemical species or the oxidation state of redox sensitive elements. In the context of successful planning of remediation strategies for contaminated sites this chemical information is categorically needed. In addition, chemical sensitivity as well as post processing methods extracting trace chemical information from a complex geo-matrix are required.

The presentation will give examples of homogeneous and heterogeneous nucleation of nanoparticles [5], the speciation of radionuclides through incorporation in these newly formed phases [6], the changes of surface roughness and charge heterogeneity and its impact on nanoparticle mobility [7] and the sorption of organic colloids on mineral surfaces leading to functional group fractionation and consequently different metal binding environment as unraveled by time resolved laser fluorescence measurements [8]. Furthermore, aquifer flow path heterogeneity is driving the mobility/retention of colloids/nanoparticles, which can be resolved by tomographic (CT) methods [9]. Reactive transport models use usually simplified geometrical assumptions which are essential to properly predict pore clogging. Here, implementation of 3D μCT information will overcome these shortcomings. Examples of contaminant transport up-scaling from laboratory scale (μm-dm) to field scale experiments in underground research laboratories (URL's) will be discussed and based *inter alia* on the examples given current challenges and potential new directions will be highlighted in the presentation.

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