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Colloid and colloid-facilitated transport in fractured rocks

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Fractures are likely to be favorable carriers for colloids and nanoparticles due to their large aperture, enabling relatively high flow velocity and smaller tortuosity of the flow path in comparison to flow through the surrounding rock matrix. Here, we will briefly summarize years of research concerning colloid and colloid-facilitated transport in fractures. We will discuss: (1) processes in the unsaturated zone, where fractures are exposed to wetting and drying cycles which enhance the release and mobilization of colloids from fracture surfaces and filling materials; (2) the relationship between colloid properties and mobility within saturated systems; (3) the impact of groundwater salinity on colloid transport; (4) colloid facilitated transport of Pb, Cs , Cr and NZVI's; and (5) finally, large scale field experiments examining the mobility of colloids in fractures.
Our results demonstrate that wetting and drying cycles in fractures crossing the upper vadose zone result in release and mobilization of fine particles. Experiments carried out in saturated fractures indicate high recovery of large microspheres (0.2 and 1 micron) and lower recovery of the small spheres (0.02 micron). It was observed that clay particles exhibit lower recoveries than the microspheres (50% and 90%, respectively) due to their higher density (2.65 vs. 1.05 g/cm3). In all cases, arrival times of colloids were earlier than that of the reference species, bromide or uranine. It was found that colloid-facilitated transport played a major role in the migration of lead, cerium and cesium through fractures. In the case of cerium, intrinsic colloids formed through the precipitation of Ce2(CO_3)3 resulted in cerium's increased mobility. Work on NZVI particle transport through fractures showed that the particles' mobility was linearly correlated with gravitational stability.
In conclusion, it was observed that in many cases, fractures are favorable carriers for colloids and facilitate colloid-associated transport of contaminants with high affinity to the solid matrix. It was found that even on a large scale, fractures may enable massive transport of colloidal matter. However, each colloid and contaminant should be explored under relevant geochemical and physical conditions to best predict environmental behavior.