Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.13939

Effects of kaolinite on the transport of ferrihydrite colloids in underground environment

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Ferrihydrite colloids occurs ubiquitously in the natural environments and is well-known to play a vital role in the fate and mobility of contaminants. Most research of colloids centered on the transport of colloids in varying physicochemical perturbations conditions, and believed that the colloids migration was hindered when agglomeration happened. However, the colloids transport is also affected by the properties of the solid medium surfaces. Clay mineral is a significant component of the porous media in aquifers, the impact of minerals on colloids transport is largely overlooked. Taking the kaolinite as an example, the clay mineral how and to what extent modulated the transport of ferrihydrite colloids was investigated via column experiments, batch experiments, isothermal titration calorimetry (ITC), X-ray absorption fine structure (XAFS), and density functional theory (DFT) calculations. Our results reveal that the kaolinite coated sand column has the stronger inhibition effect than the sand column on the mobility of ferrihydrite colloids. The estimated maximum travel distance of ferrihydrite colloids under the absence of kaolinite reach 9.8-fold larger than that in the presence of kaolinite. The reduced travel distance was primarily attributed to the adsorption of ferrihydrite colloids by kaolinite, with the maximum ferrihydrite colloids adsorption capacity was 19.8 mg g^{-1} for kaolinite. The ferrihydrite colloids cannot remobilized from the column under the presence of kaolinite by changing pH value and ionic strength. This may be due to the inner-sphere complexation formed between the ferrihydrite colloids and kaolinite, and the assumption was confirmed by the results of isothermal titration calorimetry (ITC). The results of XAFS and DFT calculations revealed that ferrihydrite colloids coordinated to the surfaces of kaolinite via the formation of monodentate inner-sphere complexes, and exhibited high thermodynamic stability. These new findings will help to understand the transport behavior and mechanism of ferrihydrite colloids in underground environments, and provide a scientific basis for prediction of the contaminants behavior in the environments.