

On the use of hydrochemical mixing models to conceptualize hydrogeology in fractured rocks

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Abstract

Mixing models are broadly used in hydrogeology as a tool to understand groundwater systems. Simple mixing models are based on inferring the relative abundance of assumed end-member waters from measured concentrations of conservative species in the mixture. However, simple mixing methodologies present clear limitations for complex systems with the influence of several initial and boundary waters. For these cases, more sophisticated mixing models have to be used by using statistical multivariate techniques such as Principal Component Analysis.

On the other hand it is also known that mixing modeling presents practical limitations, basically derived from the uncertainties in the definition of the end-members, as well as mixing artifacts associated to groundwater sampling procedures by drilling and pumping, that use to magnify the apparent mixing in the system.

In addition to the abovementioned practical limitations, we claim in this work that mixing models are also subjected to conceptual limitations that can lead to serious misuses, especially when applied to fractured rocks. This is due to the fact that matrix diffusion phenomena introduce a “memory” effect in the system previously affected by the influence of different waters. This fact could make mixing modelers to misunderstand the real groundwater behavior. We present a series of synthetic numerical simulations to illustrate that hydrogeological models based on computed mixing models, of known end-member waters, are unable to properly conceptualize the real hydrogeological behavior of a fractured rock aquifer.

Mechanisms governing nanoparticle transport in porous media

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Abstract

The prospect of using engineered nanoparticles for subsurface applications raises practical questions. How far can nanoparticles be transported through porous media? If multiple fluid phases are present, does this affect the transport distance? Do the nanoparticles travel at their injected concentration and at the velocity of the carrier phase? The science needed to answer these questions raises its own set of interesting problems. Can nanoparticle transport be treated like solute transport, or must the nanoparticles be treated like colloids? If the latter, what forces govern the interaction between nanoparticle and the solid surface of the porous medium? If nanoparticles attach or adhere to the solid, can they detach? Is the nanoparticles/solid interaction reversible? In this talk we review a large set of transport experiments conducted in our laboratory. The data provide some insight into key mechanisms of nanoparticle transport and retention. For example, we typically observe small amounts (much less than a monolayer) of irreversible adsorption, and even smaller amounts of reversible adsorption. Experiments with variable flow velocities indicate that nanoparticle adsorption capacity is a dynamic, hysteretic property. For suitably engineered particle coatings, particle adhesion at fluid/fluid interfaces is the same magnitude as adhesion on the solid surface. We discuss a framework for modeling these phenomena.