Modélisation de transfert de matières dissoutes et particulaires dans un milieu fracturé

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Abstract

In order to face the emerging problems of pollution and deterioration in water quality, it is necessary to master the hydrogeological functioning of pollutant-receiving rocks. This involves, defining the vulnerability of aquifers and optimising the modelling of the retention phenomena and transport mechanism of particles in rocks. In karstic aquifers, fractures serve as preferential pathways for particles, thus allowing their rapid transport. The transport of particles and dissolved matter in fractures is governed by advection and dispersion which are influenced by several factors. The objective of this study is to contribute to a better understanding of the mechanisms of transport of solid particles and dissolved matter in fractures and the different factors influencing these mechanisms. For this purpose, an experimental program was developed to understand the influence of flow velocity, fracture aperture, fracture orientation and ionic strength on the transport of kaolinite particles and fluorescein dissolved tracer in fractured chalk samples. In addition, a numerical model was developed based on the Advection-Dispersion equation, to determine the transport parameters and deeply understand the particle-fracture surface interactions under different conditions. The results of this study revealed that the hydrodynamic effect is significant regardless of fracture orientation, with particle recovery increasing as flow velocity increases. Kaolinite particles travel faster than fluorescein due to the size exclusion effect and the higher dispersion coefficient of fluorescein. The attachment coefficient increases with flow velocity for all fracture orientations and is independent of fracture aperture. Conversely, the detachment coefficient, which is negligible for small flow velocities, is greater in smaller apertures due to higher shear stress. The findings showed that fracture orientation significantly affects the transport of kaolinite particles but has a negligible impact on fluorescein as a dissolved tracer. Increasing the fracture orientation vertically enhances particle recovery and dispersion, while the attachment coefficient decreases. The effect of ionic strength indicate that higher ionic strength increases particle retention and decreases the recovery rate. With the attachment coefficient exhibiting a linear increase and the detachment coefficient follows an exponential trend with increasing ionic strength. The study findings highlight the importance of considering high flow velocities in studying the hydrodynamic effect, fracture aperture, and IS effect in understanding micron-sized particle transport mechanisms in chalk fractures. It also contributes to the advancement of understanding the effect of fracture orientation on the transport of particles by using experimental methods. These understandings are essential for assessing risks to groundwater resources and advancing environmental protection measures.