Field scale characterisation of solute transport and biogeochemical reactivity in fractured media

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Understanding biogeochemical reactions in aquifer is important for the prediction of contaminant transport in aquifers and for groundwater management. These reactions result from the capacity of aquifers to transport of chemical elements and from the ability of microorganism communities to use these elements for their development. Therefore, experiments accounting for groundwater conservative and reactive transport as well as changes in microorganism communities are essential to understand the biogeochemical reactivity at field scale.

This study presents the results of a groundwater tracer test using the combined injection of dissolved conservative and reactive tracers (He, Xe, Ar, Br^-, O_2 and NO_3^-) in order to evaluate the transport properties of a fractured media in Brittany, France. Dissolved gas concentrations were continuously monitored *in situ* with a CF-MIMS (Chatton et al, 2017) allowing a high frequency (1 gas every 2 seconds) multi-tracer analysis (N_2, O_2, CO_2, CH_4, N_2O, H_2, He, Ne, Ar, Kr, Xe) over a large resolution (6 orders of magnitude). Along with dissolved gases, groundwater biogeochemistry was monitored through the sampling of major anions and cations, trace elements and microbiological diversity (metagenomic analysis).

Dissolved noble gas data enabled the characterisation of the dominant physical transport properties of a fractured media using a double porosity model. These findings enabled the subsequent modelling of the nitrate breakthrough curve and the derivation of a reactive transport model based on a first order kinetic reaction of denitrification. The continuous monitoring of groundwater chemistry and microbiology allowed the identification of pyrite and biotite as reactive minerals involved in the denitrification reaction which is mediated by autotrophic microorganisms. The sudden availability of nutrients in the anoxic fractured media resulted in significant modifications in microorganism communities particularly a fast and ample growth of denitrifying and sulphur-oxidising bacteria.

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