Geophysical Research Abstracts
Vol. 15, EGU2013-11426, 2013
EGU General Assembly 2013

Modeling seawater intrusion and the associated reactive solute transport in fractured coastal aquifers

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In coastal aquifers seawater and terrestrial water get into contact and the reactive mixing between these water bodies controls the water quality of submarine groundwater discharge. The rates of such mixing controlled reactions are depending not only on the properties of the reactive species but also on the density driven flow dynamics and the resulting transport patterns. A prediction of these flow and transport processes and thus of the fate of reactive species is specifically challenged in fracture aquifers as it depends on the focusing of the flow and the local balance of viscous and gravitational forces.
To study the influence of fractures on mixing and reactive transport in coastal aquifers we present a reactive discrete fracture and matrix (DFM) model using unstructured spatially adaptively refined finite-element meshes. This model is developed by coupling the Complex System Modelling Platform (CSMP++) utilizing a hybrid FEFV scheme, and a Biogeochemical Reaction Network Simulator (BRNS) capable of solving for kinetically and thermodynamically constrained biogeochemical reactions [1]. The model is applied to simulate the reactive transport in fracture networks embedded in a permeable rock matrix. For virtual coastal aquifers, different fracture data sets are employed to study the effect of fractures and their characteristics on the reactive mixing between fresh water and seawater in coastal aquifers.
Obtained results show that the presence of fractures enhances reactive mixing for most cases due to the combined effect of fracture induced flow channeling and dispersion. The magnitude of this effect depends highly on fracture density, spacing and orientation. Furthermore the results indicate that reactive mixing in fractured aquifers is not well described using an effective parameterization of a homogeneous aquifer setup. This suggests that structural information on the fracture network is needed for a sufficient description of reactive transport processes in fractured coastal aquifers.

References:
1- Nick, H.M., et al., Reactive dispersive contaminant transport in coastal aquifers: Numerical simulation of a reactive Henry problem, Journal of Contaminant Hydrology, in press.