Mixing and calcite dissolution in heterogeneous coastal aquifers — A numerical 2D study

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ABSTRACT
Mixing across the saltwater-freshwater (SW-FW) interface has become a subject of growing interest due its relevance in groundwater management and remediation activities within coastal environments. Mixing and dispersion are key processes that affect a range of geochemical processes, including the formation and development of karsts, exchange reactions and biochemical processes. The evolution of the SW-FW is strongly influenced by the density difference between salt and freshwater as well as temporal flow fluctuations induced, for example, by sea level fluctuations and the inherent hydraulic and chemical heterogeneities within a given system. Exploring these processes in a hydraulically heterogeneous setting has been shown to enhance mixing and widening of the SW-FW interface. In order to gain further insight into how these typical (coastal) transient processes affect mixing processes, we conceptualize variable density flow in a heterogeneous system coupled with reactive transport. For this purpose, we use the COMSOL Multiphysics® software to model flow and transport. In order to account for calcite dissolution and the reaction rate, a mixing ratios-based formulation presented by De Simoni (2005, 2007) is used. We quantify the reaction rate and the change in porosity to further highlight the development of reactive hotspots that result from zones of enhanced mixing and flow deformation.

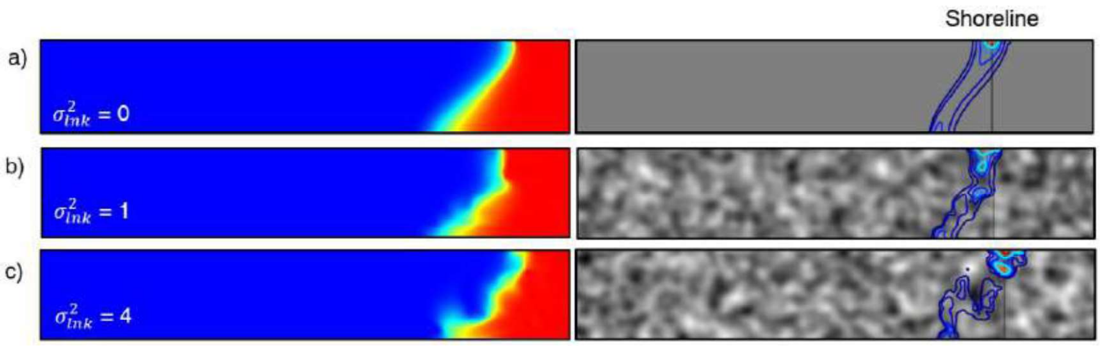

Figure 1. Example of simulated salinity distributions and porosity change for homogeneous media and heterogeneous media. Each model is simulated until steady-state is achieved with the porosity contours representing changes in porosity every 10,000 years. The heterogeneous media is represented by a simulated Gaussian field with a hydraulic conductivity geometric mean of 5e-4 m/s and a σ^2_{lnk} of 1 and 4. The images are snap shots of a 1500 m by 100 m model domain at horizontal extents x = 850 m to 1300 m over the entire height of the domain.

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