Effects of periodic temporal fluctuations and fluid density effects on mixing and chemical reactions in coastal aquifers

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ABSTRACT

3Mixing and chemical reactions in coastal aquifers are strongly influenced by the variability in the spatial distribution of hydraulic and geochemical properties of the subsurface and periodic temporal fluctuations on multiple time-scales. We investigate effective mixing and solute transport in temporally fluctuating flow and their impact on chemical reactions in coastal aquifers. For the reactive transport system the geochemical setup of calcite dissolution-precipitation is considered. We first study the effect of the coupling of heterogeneity, density variations and short-period fluctuations on an horizontal freshwater-seawater interface with a stable density stratification. To this end, multigaussian random log-conductivity fields are simulated and more complex fields characterized by connected patterns of high and low conductivity. We find that the magnitude of transient-driven mixing is mainly controlled by the hydraulic diffusivity, the period, and the initial interface location. We also find that the coupling of structural heterogeneity, transient forcing and density-driven flow leads to complex reaction patterns where the mass transfer mechanisms control the configuration of the conduits and cave formation (Pool and Dentz 2018). Then, we extent the analysis to account for the characteristic freshwater-seawater convection cell under sea-level fluctuations on scales of millennia. Porosity and permeability changes in response to the dissolution of calcite are considered. We investigate the mixing dynamics and quantify its impact on the reaction efficiency and the configuration of the karst development. We find that when long period fluctuations are considered, maze dissolution network patterns emerge where the 'hot spots' are directly related to the density gradients driven by the long-period temporal fluctuations.

REFERENCES

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