



Effects of sea level changes and fluid density variability on calcite dissolution in coastal aquifers

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Chemical reactions in coastal aquifers are strongly influenced by mixing of freshwater and seawater due to seawater intrusion (SWI) and periodic flow fluctuations on multiple time-scales. Here we study mixing and solute transport in temporally fluctuating flow in coastal aquifers and their impact on the dissolution of calcite. Two-dimensional variable-density flow and transport simulations are performed with different chemical compositions of the two end-members (fresh and seawater) that account for 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 increasing porosity and the configuration of dissolution network patterns. We find that the CO_2 pressure (P_{CO_2}) of both end-members plays a key role in the porosity increase. Thus, the calcite dissolution rate is much larger when freshwater has a high P_{CO_2} . However, similar dissolution patterns are obtained for all the different end-members characterized by dissolution 'hot spots' that are directly related to the concentration gradients driven by buoyancy effects and changes in the sea level. We also find a close relationship between the nature of sea level fluctuations and the formation of complex reaction patterns (conduits and cave distribution). Thus, our results suggest that (1) calcite dissolution is always maximum when the sea level rises from global or local minima, (2) regular long period fluctuations promote the formation of very large horizontal conduit networks, and (3) irregular and short period fluctuations favor the formation of sinkholes and vertical karst dissolution.