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Mineral replacement front propagation in deformed rocks

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Fluid migrations are a major agent of contaminant transport leading to mineral replacement in rocks, impacting their properties as porosity, permeability, and rheology. Understanding the physical and chemical mechanisms that govern mineralogical replacement during and after deformation is required to better understand complex interplays between fluid and rocks that are involved in faulting, seismic cycle, and resource distribution in the upper crust. Dolomitization process related to hydrothermal fluid flow is one of the most studied and debated replacement processes in earth sciences. Dolomitization of limestone is of economic importance as well, as it stands as unconventional oil reservoirs and is systematically observed in Mississippian-Valley Type ore deposit. Despite recent breakthrough about dolomitization processes at large-scale, the small-scale propagation of the reaction front remains unclear. It is poorly documented in the occurrence of stylolites and fractures in the medium while pressure-solution and fracture network development are the most efficient deformation accomodation mechanism in limestone from early compaction to layer-parallel shortening. Thus, the impact of such network on geometry of replaced bodies and on replacement front propagation deserves specific attention.

This contribution illustrates the role of fracture and stylolites on the propagation of a reaction front. In a 2 dimensional numerical model we simulate the dolomitization front propagation in a heterogeneous porous medium. The propagation of the reaction front is governed by the competition between advection and diffusion processes, and takes into account reaction rates, disorder in the location of the potential replacement seeds, and permeability heterogeneities. We add stylolites and fractures that can act as barriers or drains to fluid flow according to their orientation and mineralogical content, which can or cannot react with the contaminant. The patterns produced from various configurations of stylolites and/or fractures are compared in shape and dimension to natural patterns of replacement fronts observed around MVT deposits. This comparison allows discussing the impact of planar or rough heterogeneities as fractures or stylolites on contaminant transport and so it provides new insights about fluid-rocks interactions in deformed porous media.