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Microfluidics experiments of dissolution in a fracture. Influence of Damköhler and Péclet numbers, and of the geometry on the dissolution pattern

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Dissolution of natural rocks is an ever present phenomenon in nature. The shaping of natural landscapes by the dissolution of limestone gives for example birth to exceptional features like karsts. Currently dissolution is also at the heart of key research topics as Carbon Capture and Storage or Enhanced Oil Recovery. The basics principles of dissolution are well-known, however, the sheer amount of different patterns arising from these mechanisms and the strong dependency on parameters such as pore network, chemical composition and flow rate, make it particularly difficult to study theoretically and experimentally.
In this study we present a microfluidic experiment simulating the behavior of a dissolving fluid in a fracture. The experiments consist of a chip of gyspum inserted between two polycarbonate plates and subjected to a constant flow rate of pure water. The point in using microfluidics is that it allows a complete control on the experimental parameters such as geometry and chemical composition of the porous medium, flow rate, fracture aperture, roughness of the fracture walls, and an in situ observation of the geometry evolution which is impossible with 3D natural rocks. Thanks to our experiments we have been able to cover the whole range of dissolution patterns, from wormholing or DLA fingering to homogeneous dissolution, by changing Péclet and Damköhler numbers. Moreover, we have been able to tweak the geometry of our artificial fracture, inserting finger seeds or non-dissolvable obstacles. The comparison of the experimental patterns with the numerical dissolution code dissol (Szymczak and Ladd 2011) has then shown a very good correlation of the patterns, giving confidence in both experiments and modeling.