Multiscale effects of reactivity and flow rate on porosity during dissolution of carbonates

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The microstructure and evolution of pore space is an important factor controlling fluid flow in geological formations. The size, distribution, and connectivity of these confined geometries dictate how fluids migrate into and through these environments, wet and react with the surfaces. These properties are, in turn, modified by changes in the geological and geochemical conditions to which the rock is exposed. In order to interpret the history of any geological system, the "fingerprints" of this evolution must be explored over widely different length scales.

We have experimentally investigated the multiscale effects of dissolution on carbonates as a function of fluid reactivity and flow. The nature of dissolution depends on the values of the Péclet and Damköhler numbers. Variations in these parameters lead to either diffuse or compact reaction fronts, or "wormholing". Experiments were performed on slit-fractured and unfractured Indiana limestone and Carthage Marble with initial permeabilities $\sim$ 70 and 2E-06 mD respectively. HCl solutions, initial pH 2 and 4, were flowed through 1.5" OD x 6" long cores at 0.1 and 10 cc/min. For the solid cores neutron CT images documented the flow regime. Cores were then sectioned at several positions perpendicular to flow. The pore structures of each section were analyzed using (ultra) small angle neutron and X-ray scattering and imaging techniques. Significant differences were observed in the pore structure of the rock as a function of dissolution type.