The Effects of Chemomechanical Processes on Limestone Weathering

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Dissolution within porous media is a critical process in many environmental and geological settings. In general, rock dissolution rates are governed by fluid composition, fluid flow rates, and the surface area of the mineral–fluid interface. As a surface becomes rougher, the surface area in contact with a reactive fluid increases, and it is therefore often assumed that rough surfaces dissolve more rapidly than smooth surfaces. However, a complex relationship exists between roughness and reactivity. Emmanuel and Levenson (2014) found that erosion rates in fine-grained micritic limestone blocks are as much as two orders of magnitude higher than those for coarse-grained limestones due to rapid dissolution along grain boundaries followed by mechanical detachment. Such chemo-mechanical processes may be a dominant erosional mode in carbonate terrains.

To better understand this process we undertook a series of experiments looking at the weathering of four limestones (Netzer, Shivta, Carthage Marble, Texas Cream) exposed to flowing water at 30°C and several pH values to mimic weathering. Annular Cd masks of stepped sizes, and small beam stepped locations analyses, were used to analyze the weathering structure by (U)SANS and (U)SAXS as a function of distance from the edge. SEM analysis was also used to look at the pore structure and surface weathering. The results, both in terms of core/rim variations and pore size dependence, were found to be strongly dependent on initial permeability and rock structure, as well as time and pH.