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Pressure solution observed with an atomic force microscope

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Dissolution of minerals is involved in many geological and environmental processes, often with large human consequences. One can cite the durability of mineral materials, the management of nuclear wastes, the sequestration of atmospheric CO_2 or the pollution of drinking water. Progresses have been made during the last decade in our understanding of the basic mechanisms of dissolution, particularly concerning the nature of the reactive surface, the role of etch pits, the influence of the mineral history, the mineral replacement processes, ...
One of the remaining problems is the influence of an elastic stress on the nature and rate of dissolution. For instance a large discrepancy still exists between experimental results and modelling of pressure solution creep, a plastic strain mechanism of minerals based on the dissolution enhancement by an external stress.
We present here an experimental evidence of the influence of a local stress on a molecular elementary mechanism of dissolution. This was performed by atomic force microscopy observation of the migration of a molecular step on the surface of a single crystal of gypsum during dissolution, where the AFM tip is used alternatively to apply a stress and probe the surface. The kinetics of this atomic mechanism is seen to obey the same law of pressure solution as the corresponding macroscopic phenomenon.