

Does stress affect the dissolution of calcite?

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In order to understand how fluids interact with loaded rocks it is important to know how much stress affects the chemical potential and dissolution-precipitation rates of common rock-forming minerals. We investigated the effect of stress (elastic strain) on the development of dissolution patterns on free surfaces of calcite single-crystals using 'wet' Atomic Force Microscopy. Samples were stressed in the AFM by means of bending. Thin-sections (80 μm) of Iceland Spar crystals were prepared on a microscope cover glass (200 μm) and glued into a concave holder with constant curvature. Stress-distributions in the elastically bend doubly-layer were calculated by numerical modeling. Calcite samples were curved to a degree close to the elastic limit in compression, i.e., just below the critical curvature at which first mechanical twins were observed. The initial sample surface was ultrapolished, either parallel to (10-14) cleavage planes or, to increase the number of initial reaction sites, inclined to these crystallographic planes by 5 degrees. Experiments were carried out in freshly deionized water and ran for up to 3 hours.

The surface patterns of the 22 studied samples (12 stressed, 10 stress-free) showed significant variation, making it difficult to determine whether an effect of stress on pattern formation existed. Sample surfaces polished parallel to (10-14) showed dissolution by etch-pit formation, both with and without stress. Sample surfaces inclined to (10-14), both with and without stress, dissolved along parallel steps not originating from dislocation, but (like etch-pit walls) with a preferred orientation parallel to one of the cleavage plane direction. After strong initial (~30 minutes) bunching of dissolution steps, an apparent steady state pattern was usually reached with only minor variation across a single sample surface. From sample to sample much variation existed in the length and width of terraces in between bunched dissolution steps. Compared to stress-free samples, stressed samples showed more heterogeneous dissolution patterns on the micrometer scale and, on average, a higher number of growth features, preferably at elevated (stress-free) sites on the roughening sample surfaces.

Modelling localized volume changes: Application to pressure solution and stylolites

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A newly developed two-dimensional elasto-plastic numerical model is used to study the evolving interaction between stress distribution in a soluble elastic matrix and a resulting pressure solution (PS) distribution. Spatial distributions of PS resulting from different dominant PS mechanisms are compared (e.g. thin-film and undercutting). The model is used to study growth of a single stylolite, as well as stylolite interactions under a variety of boundary conditions. Results suggest that 1) Other PS mechanisms in addition to (or instead of Thin-Film PS take place in stylolites. 2) Spacing between stylolites might be controlled by elastic mechanisms and rock heterogeneity, similarly to controls on spacing between cracks and compaction bands.

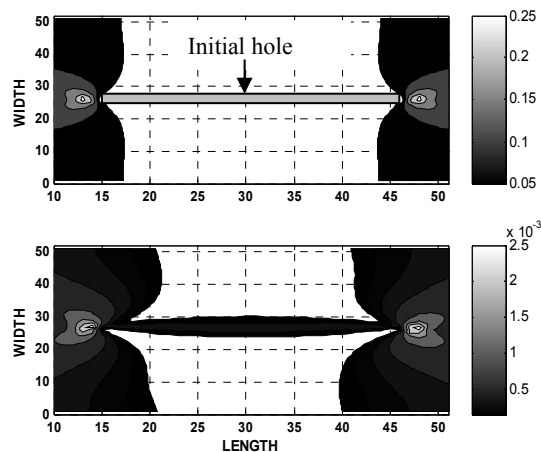


Figure 1. PS evolving around a compressed crack. Gray shading indicates rates of dissolution in non-dimensional units (here white is used for the highest dissolution, black for the lowest one; white area with grid in the middle of the picture corresponds to area where there is no dissolution occurs). a) Dissolution resulting from PS dominated by normal stress (thin-film) is concentrated at the crack tips. b) PS controlled by strain-energy (undercutting) is concentrated both at the tips and the walls of the initial crack.