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Does stress affect the dissolution reaction 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 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 double-layer were calculated by numerical modeling. The curvature of the calcite samples was 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 initial number of 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 the assessment of effects of stress on pattern formation difficult. 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 an width of terraces in between bunched dissolution steps. Compared to stress-free samples, stressed samples showed more heterogeneous dissolution patterns on the microme-

ter scale and, on average, a higher number of growth features, preferably at elevated (stress-free) sites on the roughening sample surfaces. The observations suggest that stress enhances the surface reaction rate of calcite and drives replacement of stressed by unstressed material.