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Dissolution of the periclase (001) surface: A scanning force microscope study

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ABSTRACT

In contrast to most ionic minerals studied by SFM, the periclase (001) surface dissolves not by retreat of monolayer steps parallel to (001), but by retreat of a rough surface perpendicular to (001). At pH < 2, dissolution has an additional contribution from retreating macro-steps at the edges of nearly square pits. The macro-steps have heights up to 120 nm. In general, step direction is parallel to [110] and equivalent directions. During dissolution at low pH, a soft near-surface region is formed. Other investigators have shown that the near-surface region is protonated. Protonation is supposed to stabilize the (111) surface of periclase. Due to the structural similarities between periclase (111) and brucite (001), and similar dissolution rates of periclase and brucite at pH < 5, we conclude that during dissolution the periclase (001) surface is restructured into ''(111) nano-facets'' representing brucite (001)-like layers and appearing as a rough and soft surface in SFM images. The most probable reasons that the slopes of these macro-steps (up to 50°) are lower than the slopes of perfect (111) facets are the likely poorly ordered structure of these layers, microtopography on these surface facets, and tip-surface convolution in SFM. By measuring the vertical position of the surface vs. time, we calculated the dissolution rate. At pH 1 and pH 2 we found the rates to be $17.1 \pm 5.8 \times 10^{-6}$ and $5.7 \pm 3.7 \times 10^{-6}$ mol/m^2·s, respectively. These rates are in reasonable agreement wol with previously reported rates of periclase and brucite (001) dissolution, and are consistent with the idea that the MgO (001) surface consists of $Mg(OH)_2$ (001)-like layers.