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Incongruent dissolution of wollastonite measured with vertical scanning interferometry

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ABSTRACT

In this study, we investigated the dissolution kinetics of wollastonite, a pyroxenoid with composition $CaSiO_3$, at earth-surface temperatures. We used vertical scanning interferometry (VSI) to quantify the surface normal retreat (or advance) of a crystallographically defined cleavage face on a single wollastonite crystal as a function of time. Nanometer-scale measurements of (100) faces show that the wollastonite surface undergoes a net expansion normal to the surface and relative to the pristine mineral surface. These observations were made during the dissolution process at acidic conditions. The swelling is the result of the formation of a cation-depleted layer at the wollastonite-water interface. We combined VSI measurements with electron microprobe measurements to track the chemical evolution of the leached layer during dissolution, and then used previously reported Ca release rates to calculate the density of the cation-depleted layer. Using an average Ca release of 9.09×10^{-9} mol/m^2·s at pH 3 and 25 °C, the density of the leached layer is 1.2 g/cm^3, and grows to a thickness of ~50 nm after 20 hours of reaction. Although our observations do show direct evidence of the formation of a cation-depleted layer during dissolution, they do not favor a particular mechanism of formation of this layer. At this time, our results cannot rule out either cation migration through the depleted crystal structure or re-precipitation at the mineral surface.

Keywords: wollastonite, dissolution kinetics, leached layer, interferometry, mineral dissolution, surface studies