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WHAT LURKS IN THE MARTIAN ROCKS AND SOIL? INVESTIGATIONS OF SULFATES, PHOSPHATES, AND PERCHLORATES

Etch-pit size, dissolution rate, and time in the experimental dissolution of olivine: Implications for estimating olivine lifetime at the surface of Mars†

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Abstract

Various approaches have been used to estimate when and how long liquid water was present at the surface of Mars. The olivine dissolution-lifetime application suggested by Stopar et al. (2006) and Olsen and Rimstidt (2007) is here adapted and tested at the scale of individual etch-pits using published data from an experimental system in which the volume of mineral removed and the duration of the mineral-removal episode are known. Different assumptions about the specific geometry of etch-pits on olivine result in surface-area estimates that vary by less than a factor of two from the simple hemispherical pit used in the calculations. Given that other sources of uncertainty in mass-time relationships of silicate-mineral dissolution during natural weathering can be up to four orders of magnitude, the effects of differing geometric assumptions about the shapes and surface areas of the etch-pits are negligible.

Using compiled experimentally determined forsterite dissolution rates and the imaged etch-pit sizes from experiments recovers the duration of the experiment that produced the imaged etch-pits to within less than a factor of two. This suggests that extensively etched olivine surfaces imply a dominance of the etch-pit walls over the bulk surface between the etch-pits during olivine corrosion. The approach adopted here recovers the timescales of experimental etch-pit production on olivine at STP and extreme undersaturation of the solution with respect to olivine in experiments where pH is known. Continued progress in understanding the fundamentals of olivine dissolution kinetics will narrow the ranges of uncertainty in mineral-lifetime estimates at Mars' surface in support of constraining the compositions and duration of potentially habitable aqueous solutions on Mars.

Keywords: Olivine, geochemical kinetics, dissolution, etch-pits, Mars