

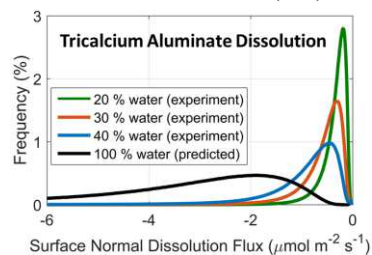
## Applications of *in situ* digital holographic microscopy in geochemistry and civil engineering

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Digital holographic microscopy (DHM) is a novel interferometric method for obtaining fast, *in situ* micro- and nanoscale characterization of surface topography. Submicron lateral resolution and potentially subnanometer vertical resolution can be achieved with a time resolution of 80 ms. Complementary to previous geochemical experiments with atomic force microscopy (AFM) and vertical scanning interferometry (VSI), DHM offers an advantage of capturing full 3D topography data under *in situ* solution conditions. As has been demonstrated by AFM and VSI experiments (*e.g.*, [1]), DHM has also confirmed that the dissolution of crystalline materials is better described through a probabilistic distribution of fluxes. Using *in situ* DHM, the dissolution kinetics have been evaluated for Iceland spar calcite [2], gypsum [3], tricalcium aluminate [4], and  $\beta$ -dicalcium silicate. With the rapid collection of 4D data, it was demonstrated that calcite (104) exhibits dissolution spectra



that vary spatially and temporally [2], and investigations of gypsum (010) provided evidence of shallow and deep etch pits as well as rapidly dissolving stepwaves [3]. For studies of civil engineering materials, namely mineral phases found in portland cements, which react very quickly, the dissolution kinetics were evaluated as a function of water activity, and it was found that the dissolution morphologies and rates were spatially heterogeneous [4]. For cement minerals, on-going work is coupling the DHM data to the possible mechanism (*e.g.*, congruent *vs.* incongruent dissolution, interfacial dissolution-reprecipitation).

- [1] Fischer *et al.* (2014) *Appl. Geochem.* **43**, 132-157. [2] Brand *et al.* (2017) *Geochim. Cosmochim. Acta* **213**, 317-329. [3] Feng *et al.* (2017) *Chem. Geol.* **460**, 25-36. [4] Brand and Bullard (2017) *Langmuir* **33**, 9645-9656.