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Characterizing isotropic and anisotropic mineral surfaces using roughness parameter distributions

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Dissolution and precipitation as well as abrasion are the basic physico-chemical processes that modify the topographical characteristics of surfaces. In geosciences, a prime interest in the quantification of a mineral surface area is its use to normalize rates. For practical reasons, the BET (or total) surface area is mostly used in mineral dissolution studies. However, what part of the surface is reacting and how surface area and thus surface topography change with time is often not well documented in dissolution studies. On the other hand, atomic force microscopy (AFM) has been able to document changes in microtopography and step velocities. These gave valuable insight in the basic reaction steps at nanoscale but the method is generally limited by the small scanning area and the maximum roughness which can be measured.

Recently, topographic methods like vertical scanning interferometry (VSI) as well as confocal microscopy have been introduced to directly measure dissolution rates and surface roughness. Though they offer new insides into the reaction mechanisms and surface reactivity at mesoscopic length scales. Furthermore, they allow a systematic determination of surface roughness parameters. As statistical quantities roughness parameters are strongly dependent on the field of view of the used technique, on its lateral and vertical resolution and on the sampling size. The concept of 'converged roughness parameter' [1] was shown to be very useful to characterize certain surface building blocks by employing recurrent (squared) bisections of the measuring field with an edge length of a. A surface parameter is defined as converged when a flat slope is found in the convergence graph (roughness parameter versus edge length a).

The presented method calculates a high number of surface roughness parameters from topographic data as function of sampling size and enables to analyse and visualize complete roughness parameter distributions. In this process, the used topographical data can be produced by any metrological technique. Roughness parameter distributions prove to be useful to quantitatively describe critical length scales of surface building blocks on isotropic and anisotropic mineral surfaces and are insensitive to artefacts or inaccurately measured surface points. For heterogeneous surfaces, a number of maxima in the roughness distributions indicate evidently components with different surface roughness. Given examples include heterogeneous mineral surfaces from dissolution experiments as well as artificially machined surfaces.

[1] Fischer, C. & Lüttge, A. (2007) Am. J. Sci. 2007, 307, 955-973.