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Nanoscale evolution of fractured quartz surfaces in air, revealed by high resolution atomic force microscopy

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We think of a mineral surface as static but at the molecular level, it is dynamic. High resolution atomic force microscopy (AFM) has provided physical and chemical information about the structure and composition on the fracture surface of quartz at the nanoscale – and its change with time. Such observations offer new insight into post-fracture mineral reactivity, deformation and the physicochemical properties of silicate materials. We characterised freshly fractured quartz surfaces over hours to months. Benefiting from the sensitivity of AFM and the associated family of scanning probe techniques, we captured subtle morphological and chemical changes that are not accessible using conventional microscopy, which demonstrate that quartz surfaces are not static. Previous publications showed that calcite surfaces recrystallise (Stipp et al. 1996) and elements from fluid inclusions form patches on the surface (Stipp et al. 1998). That quartz undergoes the same processes is surprising because of its very low solubility.

Immediately after fracture, we observed nucleation and progressive growth of distinct patches of a different phase, which are consistent with material emerging from fluid inclusions. We studied the nucleation, spatial extent and height evolution of these patches. Despite the intrinsic conchoidal nature of quartz fracture surfaces, nanometre scale steps form from fracturing, that indicate a tendency toward localised, cleavage-like behavior at the nanoscale. The edges of these steps evolve with time. Some undergo a form of edge decoration and reconstruction, developing flanged rims where height scales proportionally with the height of the original step. These results have implications for our fundamental understanding of mineral-water interactions, helping to explain recrystallisation under diagenesis. From the applications perspective, quartz has long been considered inert. Surface evolution rates are slow, and the mass of material moved is low but not negligible on geologic time scales.

References:

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