Insights into the Interface between K-Feldspars and Water with Two- and Three-Dimensional Atomic Force Microscopy

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Clouds play an important role for the earth's climate. Their physical properties are determined, among other things, by ice particles in the clouds. The formation of ice takes place in absence (homogeneous nucleation) and presence (heterogeneous nucleation) of ice nucleating particles (INP). An example for INPs are potassium-rich feldspars (K-feldspars), which start nucleating ice at -18 °C.

Unlike other INPs, such as silver iodide, the natural cleavage planes (001) and (010) of K-feldspars have no ice-like structure. Several other reasons (*e. g.*, initialization of ice-like structures above the first water layer, surface hydroxyl groups and topographical defects) are discussed in the literature with respect to the effective ice nucleation of K-feldspars. In a recent work, the (100) plane of K-rich feldspar, which could be exposed in cracks, has been discussed as possible origin for the high ice nucleating efficiency. This has been explained by its structural similarity with the secondary prism plane of ice I_h [1].

The interface between K-feldspars and water is of great interest to understand the mechanism of ice nucleation. Therefore, we investigate the water structure at the interface of two different K-feldspars (orthoclase (001) and (010) and microcline (001)), using two- and three-dimensional atomic force microscopy. These two K-feldspars differ in their crystallographic structure. Our high-resolution two-dimensional AFM images reveal patterns that can be assigned to atomic structure of the underlying feldspar surfaces. In our three-dimensional AFM experiments, we observe periodic structures normal to the surface in a range between 6 and 7 Å, that originate from the hydration layers at the interface. These insights into the water-feldspar interface can serve as a benchmark for theoretical studies and will contribute to unravelling the high ice nucleating efficiency of K feldspars.

[1] A. Kiselev, F. Bachmann, P. Pedevilla, S. J. Cox, A. Michaelides, D. Gerthsen, and T. Leisner, Science, **6323**, 367-371 (2017)