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Effect of ageing of K-feldspar on its ice nucleating efficiency in immersion, deposition and contact freezing modes

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Recently K-feldspar was identified as one of the most active atmospheric ice nucleating particles (INP) of mineral origin [1]. Seeking the explanation to this phenomena we have conducted extensive experimental investigation of the ice nucleating efficiency of K-feldspar in three heterogeneous freezing modes. The immersion freezing of K-feldspar was investigated with the cold stage using arrays of nanoliter-size droplets containing aqueous suspension of polydisperse feldspar particles. For contact freezing, the charged droplets of supercooled water were suspended in the laminar flow of the DMA-selected feldspar-containing particles, allowing for determination of freezing probability on a single particle-droplet contact [2]. The nucleation and growth of ice via vapor deposition on the crystalline surfaces of macroscopic feldspar particles have been investigated in the Environmental Scanning Electron Microscope (ESEM) under humidified nitrogen atmosphere. The ice nucleation experiments were supplemented with measurements of effective surface area of feldspar particles and ion chromatography (IC) analysis of the leached framework cations (K+, Na+, Ca2+, Mg2+).

In this contribution we focus on the role of surface chemistry influencing the IN efficiency of K-feldspar, in particular the connection between the degree of surface hydroxylation and its ability to induce local structural ordering in the interfacial layer in water molecules (as suggested by recent modeling efforts). We mimic the natural process of feldspar ageing by suspending it in water or weak aqueous solution of carbonic acid for different time periods, from minutes to months, and present its freezing efficiency as a function of time. Our immersion freezing experiments show that ageing have a nonlinear effect on the freezing behavior of feldspar within the investigated temperature range (-40°C to -10°C). On the other hand, deposition nucleation of ice observed in the ESEM reveals clear different pattern between freshly cleaved and aged mineral surfaces. This effect is especially pronounced for surfaces having different crystallographic orientations (001 and 010), with 001 being clearly preferential for ice nucleation. The factor two change of the BET effective area of the naturally aged feldspar particles is also indicative for the change in the surface morphology. Based on the IC analysis of framework cations removal from the surface of feldspar, we discuss the possible implications of this process for the interpretation of observed freezing behavior of feldspars.

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