



Contribution ID: 152

Type: Poster

Nucleation and deposition growth of ice crystals on mineral substrates

Wednesday, January 10, 2018 6:10 PM (3h 5m)

We report measurements of growth rates of ice crystals that were nucleating on feldspar mineral substrates in the environmental scanning electron microscope (ESEM) filled with the mixture of nitrogen and water vapor [3]. The linear growth velocity of prismatic and basal faces of ice crystals has been estimated from the sequence of individual ESEM frames recorded every second. Using the theoretical framework formulated by Yokoyama and Kuroda [2] and Libbrecht [3], we have been able to calculate the local values of water vapor supersaturation at ice nucleation onsets. We show that growth rates of individual crystals are extremely sensitive to local fluctuations of vapor pressure which can be affected by the presence of ice crystals in the vicinity. Using this method, we compare on-set supersaturation values for two different feldspar specimens, feldspar treated with a weak aqueous solution of H₂SO₄, and different cooling rates. Exemplary crystal features that could imply a memory effect induced at nucleation stage (stacking disorder, screw dislocation, etc.) will be demonstrated and discussed as well.

1. A. Kiselev, Bachmann, F., Pedevilla, P., Cox, S.J., Michaelides, A., Gerthsen, D., & Leisner, T. Active sites in heterogeneous ice nucleation - the example of K-rich feldspars. *Science* 355 (6323), 367 - 371 (2017).
2. E. Yokoyama and T. Kuroda, Pattern formation in growth of snow crystals occurring in the surface kinetic process and the diffusion process. *Phys. Rev. A.* 41, 2038–2049 (1990).
3. K. G. Libbrecht, Growth rates of the principal facets of ice between -10C and -40C. *J. Cryst. Growth.* 247, 530–540 (2003).

Significance statement

ESEM is a powerful tool allowing studies of ice nucleation and characterization of ice nucleating particles in one instrument. We demonstrate its ability to measure ice growth rates under precisely controlled relative humidity conditions. Our observations suggest that ice can possess stacking disordered structure even if nucleation occurred at -30C.

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Session Classification: Poster Session & Apéro Riche (apéro dîner)