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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Heterogeneous ice nucleation on dust particles sourced from 9 deserts worldwide – Part 1: Immersion freezing" *by* Yvonne Boose et al.

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The paper gives new insights in the influence of natural dusts on ice nucleation. It is the first study relating the ice nucleation to the mineral composition of the natural dust samples. The authors very well extend recent studies on the ice nucleation of mineral dusts. Natural dusts are often rather complex mixtures of different minerals and single minerals are rare. This study addresses this by analyzing the composition of the dusts as well as discussing the influences of ground and airborne sampling. Some samples were milled which may alter the mineralogical composition. The authors are well aware of the problems of the bulk analyzing techniques and address the inhomogeneity of the mineralogy of dust with particle size. The study uses well established measurement

techniques. The study is able to show that findings from single minerals are in accordance with natural dust. It was possible to show that the ice nucleation ability of natural dusts can be related directly to their mineralogical composition.

Sampling and sample treatment The decision to sample and compare air-born and ground samples is very well justified. As was stated the mineralogical composition between the used <2.5 μ m fraction and the bulk (<32) that was analyzed with XRD may vary, but the general findings are very likely not influenced as neither mineral will be totally absent. This may influence the correlations in 3.3. Nevertheless, natural dusts and minerals are rather often found to have organic and biological material absorbed on their surface. It cannot be excluded that some are left on the dust particle surface. Gently heat treatment could have been used to destroy all organic material. Secondly the dusts did undergo different treatments to produce sufficiently small grains. The surface samples were sieved or milled and with the Israel and Atacama sample two fractions were created. It is clear that the Australia and Morocco samples had to be milled due to not small enough dust fraction, but the authors give no reason why not of all other samples a milled and a sieved fraction was created. There is no clear explanation why in particular the Atacama and Israel samples were chosen. To study the effect of milling a few samples are probably sufficient, but this may lead to an increased uncertainty in the correlations in 3.3. If certain sample sites have an increased importance due to a milled and a sieved fraction.

Mineralogy analysis The authors give a good description of the shortcomings of the analysis method as well as that the composition may not be valid for the particle sizes used in the freezing experiment.

Page 4/30: Similarly, the milling of the Israel sample likely interfered with the preferred direction of the minor components in the sieved samples, leading to an observed reduction of these mineral fractions (e.g. illite, kaolinite, plagioclase) in the milled compared to the sieved sample

There is a reduction in every relative fraction apart from the very soft calcite which, as the authors state, is probably increasing due to its softness upon milling. Why are these minor components of particular interest? What is the potential explanation of the observation?

Page 7/14: Natural mechanical weathering thus likely has enhanced the clay mineral and calcite content in the 15 smaller particle fraction whereas feldspars and quartz tend to be found in the larger size fraction.

Is the same expected for the sieved and milled samples in this study? In respect to the above mentioned part, it would be important to conduct milling on all ground samples.

Page 7/20: Hence, the Atacama and Israel milled, Australia, Crete, Peloponnese and Tenerife samples consisted mainly of particles smaller than 2.5 μm and the mineralogy is representative for the particles on which ice nucleation was studied.

I suggest adding the word milled to Australia here also: Hence Atacama, Israel and Australia milled as well as the airborne samples . . . to clarify and emphasize the origins.

Immersion freezing experiments and data treatment

Dust size distribution

The authors found a bimodal fit for all samples. As a none-expert in the field of particle shapes figure 3 seems to me that this could be a result of the two used measurement techniques? Is there an explanation for the two modes based on hardness or mineral composition?

Ice nucleation of desert dust

The whole section is very well written and the authors highlight new results.

Page 10/28: As a consequence of the large mean surface area of the Great Basin sample its ns is shifted to the lowest values.

A shift can be misunderstood, maybe just: “shows the lowest ns values. “

Role of mineralogy

The first part is very well written and points out the difficulties with single minerals in case of micas, muscovite and ankerite. The authors again emphasis well that surface collected samples may not be representative for the atmosphere. In the following paragraphs the study tries to correlate ns with the mineral fractions. The aim of this is clear and the general findings may still hold true, but the statistical significance of the reported correlations is questionable. Firstly, the Pearson correlation coefficients (R) should not be used as the only statistical measure indicating the correlation. It is furthermore not clear from the text and table 5 which minerals were used at which temperature for obtaining the correlation coefficient. This information should be added to the manuscript. Including more statistical measures is probably out of scope of this study, but the regressions and plots yielding to the correlations should be added to the supplement.

In respect to the content I find the term anti-correlation of ns for illite and other clays rather confusing, independent of the fact that the values of |R|<0.5 have a low significance. Anti-correlation could be understood as an anti-freezing behavior. By increasing the content of example illite you reduce the ns at the given temperature, but in fact this is depending on the other mineral components.

The study reports that at 253K there is a good correlation between ns and the K-feldspar content, while 245K the correlation with quartz alone is better than with feldspars and quartz. The question arising is: how much of the total ns is still available at 245K to be explained by quartz if it had been already partly by K-feldspar at the higher temperature? By including a different amount of samples in the correlations at every temperature the relations are harder to identify. In my perspective it is necessary to also have a look at the correlations for the same 3 samples that were used at 253K alone at 245K and if they are better explained by quartz alone or joined by quartz and

feldspar. The authors do conduct a manual selection of which samples are included to obtain the correlation coefficient. I therefore want to emphasize once more to state which samples are taken for which correlation and to add this correlation plots to the supplement.

Minor adjustments: In figure 5 the great basin sample for me does not appear in the same color in the plot and the legend below 150

In table two what is the order of the minerals. It does not seem to be milled, sieved or airborne neither are they alphabetically sorted. Do you want to have the Israel samples on the same page?

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