

Interactive comment on “TEM analysis of the internal structures and mineralogy of Asian dust particles and the implications for optical modeling” by G. Y. Jeong and T. Nousiainen

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Reply to the comments by anonymous referee #3

We appreciate the referee's valuable comments.

Major comments

Comment 1: Most of the particles presented in this manuscript are very large (this is necessary to use FIB). However, long-range transported dust has a smaller diameter (Zender et al., JGR, 2003, 108, 4416 ; Durant et al., Prog. Phys. Geo., 2009, 33, 88). According to number distribution, most of the long-range transported dust is less than

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1 micron in diameter. In this manuscript, many inclusions/coatings/pores are hundreds of nanometers to 1 micron across (with the exception, perhaps, of some of the goethite inclusions). As a result, I would expect that individual particles the submicron fraction are much more homogeneous in structure. Consequently, I would expect that this manuscript is applicable to the optical properties of dust near the source region, but not long-range transported dust, and thus has a lower degree of applicability to retrievals. These points should be addressed in the manuscript.

Reply 1: Larger particles were used, because they are more suitable for FIB milling and provided sufficient areas for TEM analysis of structures and chemistry. Small particles are difficult to mill, because they are often not stably attached on substrate like larger particles. We are aware that TEM data of fine dust particles would be more desirable for atmospheric applications. We will try to obtain enough data from fine particles in future research, but in this pioneering publication we chose to use larger targets more easily handled. We will make a note of this in the revised version. Further, we wish to point out that, from the radiation point of view, volume/mass concentrations are more interesting than number concentrations. In Zender et al. (JGR, 2003), the mass mode of Saharan dust predicted from their model is $2\text{--}3 \mu\text{m}$ at Barbados (~ 5000 km from Sahara), while the number mode is submicron. In addition, they stated "As mentioned earlier, recent measurements from the PRIDE experiment [Reid et al., 2003] show that the transport mode of African dust is about $D_v = 3.5 \mu\text{m}$ or larger. This is significantly greater than the $D_v = 2.5 \mu\text{m}$ predicted by DEAD in the Caribbean (Figure 1) and used for our sub-bin distribution (Table 2). A larger transport mode could help to reconcile some of the disparities between DEAD and observations." Mckendry et al. (2008) reported mode of Asian dust as $2\text{--}4 \mu\text{m}$ transported $\sim 10,000$ km from an Asian source. The dimensions of most of the FIB slices are around $5\text{--}10 \mu\text{m}$, which is about double of the volume/mass mode of long-range transported dust. We think that this is not so great a difference. We expect that many structural features are inherited to finer particles of volume/mass mode of long-range transported particle size distribution. Please see Suppl. Figs. 1–5 included in the Reply to Referee #2.

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Comment 2: Clarity of figures: The imaging in this paper is beautiful, but I am concerned about the clarity of image interpretation. In particular: 1) not all of the images have scale bars, 2) the words indicating composition will be too small once the figures are the final size (could letters and a legend be used, e. g. Q = quartz, G = goethite, etc.?), 3) the lattice fringes are hardly visible and should be shown at higher magnification (a zoomed in image).

Reply 2: We found lack of scale bars in Fig. 10e and in the electron diffraction patterns of Figs. 12 and 13. They will be added in revised version. Also, the figures reveal many details if zoomed in, so the lack of these features is largely due to the small size of individual panels, which is an issue about presentation rather than the image quality. Figures will be enlarged in the final version for ACP. This is partly caused by the larger horizontal size of the ACPD page. Vertical size of the ACP page is larger than horizontal size. We will see if we can somehow enhance the features to be visible also in smaller panels without zooming. We reconsider these matters when preparing final version.

Comment 3: Other studies have performed FIB-SEM imaging of aerosol particles, and should be discussed in the introduction (e. g. mineral dust: Conny, Environ Sci Technol, 2013, 47, 8575; organic aerosol: Adler et al., PNAS, 2013, 110, 20414).

Reply 3: We will cite these two papers regarding the FIB-SEM images. Particularly, internal structures of urban dust particles imaged by SEM in Conny (2013) are very interesting.

Minor comments

Comment 1: Section 2: Some brief description of the field collections would be useful (were these samples obtained during dust storms?).

Reply 1: In spring season, the author (GYJ) monitors satellite remote sensing data and PM10 level in air which are uploaded at the website of Korea Meteorological Adminis-

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tration in almost real time. When dust storm outbreak in Asian dust sources (normally Gobi desert) is identified, we start to operate TSP dust sampler. Dust-laden air mass normally moves eastward crossing Korea, Japan, and North Pacific Ocean. The arrival time of dust is known from the PM10 data. We will add a short description about the field collection in the final version.

Comment 2: pg 6625 lines 24-26: This sentence is awkwardly worded.

Reply 2: The sentence can be modified as “In traditional ion milling, Ar ions bombard the sample surface at higher angles, making a hole in the center. The thin edge around the hole is then analyzed by TEM.”

Comment 2: pg 6627 lines 25-26: Why are the pores unlikely to be formed from dehydration? Are they too large?

Reply 2: Grain arrangement in Fig. 2c is random in overall, but subparallel locally. Long thin lenticular pores in Fig. 2c may have been formed by the dehydration and contraction of subparallel agglomerates of platy clay minerals. However, the circular pore (arrow in Fig. 2c) cannot be formed by this mechanism, but may have been formed by soil process, particularly repeated wetting-drying and freezing-sawing cycles in the dry and cool sources of Asian dust. We will add this explanation to the revised version.

Sincerely

On behalf of co-authors

Gi Young Jeong Corresponding Author

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