SUBJECT: Size Analysis of USGS NU-LHT-1M; Sample No. 018
FROM: Paul Greenberg (NASA-GRC)
DATE: July 26, 2007

The following describes the results of initial measurements of the Particle Size Distribution (PSD) of USGS sample NU-LHT-1M, Sample No. 018. I have received two samples of this material, but to date have only had the opportunity to perform initial measurements on No. 018.

Size distribution measurements were performed using a tandem arrangements of direct-reading aerosol instruments. The setup is identical to that used previously for our measurements of lunar regolith samples. The configuration is shown below in figure 1.

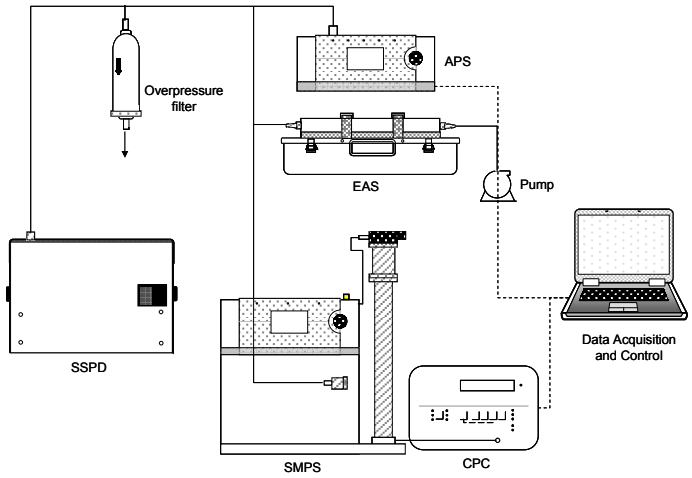

Figure 1: Experimental configuration for PSD measurements

The powder sample is dispersed using a dry platen Small Sample Powder Disperser (SSPD; TSI 3433). Although our new Electrically Assisted Sampler (EAS) has not yet arrived, our prior TEM analyses of deposited aerosolized samples indicated effective deagglomeration throughout the size range of interest. The similar trends in the data observed here tends to support a similar conclusion for this material.

Particle diameters ranging from, 0.523 to 20 μm were analyzed using an Aerodynamic Particle Sizer (APS; TSI 3321). This devices accelerates the aerosol stream through a critical orifice, then utilizes laser time-of-flight to measure the particle velocity lag relative to the surrounding gas stream. By virtue of operating in the low Reynolds Number regime, the measured lag is independent of particle density. The velocity lag is directly related to the particle aerodynamic transport diameter.

The range from 5 – 629 nm was analyzed using a Scanning Mobility Particle Sizer (SMPS; TSI 3080) paired with a Condensate Particle Counter for detection (CPC; TSI 3776). A known equilibrium charge state is imposed on the incoming sample stream, wherein the mobility distribution is obtained by sequentially scanning the applied voltage to the SMPS. The particle diameter is simply related to its mobility when the charge state is known.

Figure 2 shows the normalized PSDs for both JSC1AF and USGS NU-LHT-1M 018. While the former was mechanically pre-sieved at 20 µm, the APS uses correlated light scattering to reject particles larger than this limit, while the SMPS has a 1 µm impactor as its input. The y-axis is plotted in units of particle count number. The PSDs display reasonably similar trends, with the peak diameter of JSC1AF being roughly 3-4 times larger. The observed peak in this size region for actual regolith occurrs at a comparable value to the USGS sample, and exhibits a similar roll-off with decreasing particle diameter.

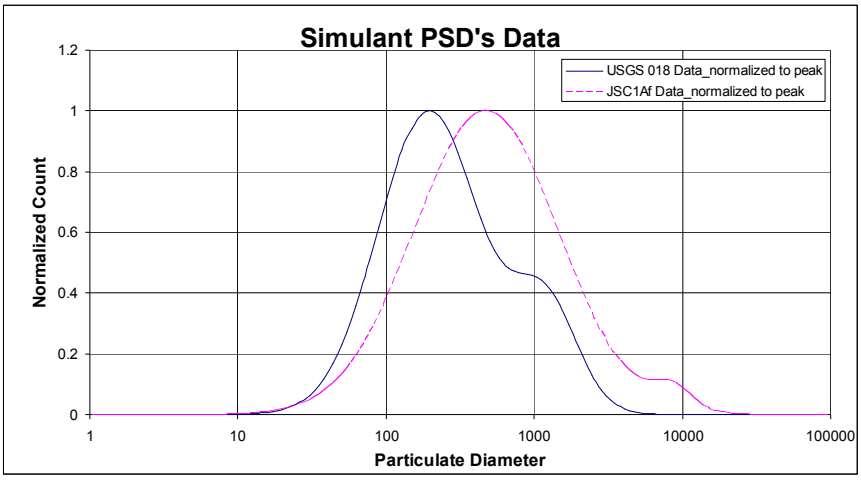

Figure 2: Normalized PSDs for JSC1AF and USGS NU-LHT-1M 018 (particle diameter in nm).

Figure 3 depicts the USGS PSD in units of mass concentration for comparison with the recent results of Alan Rawles, et al (SAP#: 10013710, 07/05/2007).

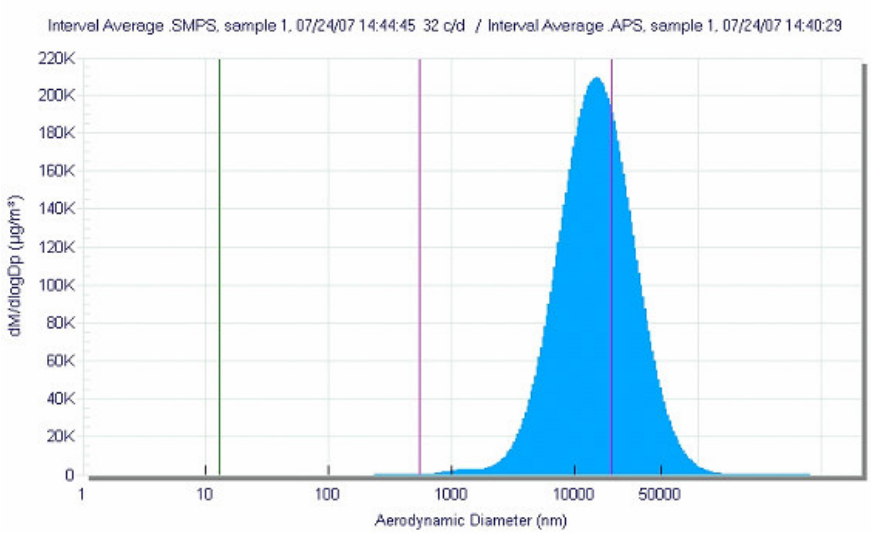

Figure 3: Mass weighted PSD of USGS NU-LHT-1M 018

While the smaller secondary peak is less pronounced relative to the analysis by Rawles, et al, the locations of both the primary and secondary peaks seen in figure 3 correspond

closely to their independent results. Both analyses also show a similar roll-off at the large end of the size spectrum. However, this observed trend is inconsistent with prior analyses, (e.g. McKay D. S., Fruland R. M., and Heiken G. H. Grain size and evolution of lunar soils. *Proc. Lunar Sci. Conf. 5th,* pp. 887–906, 1974; Heywood, H., Particle size and shape distribution for lunar fines 12057,72, *Proc. Lunar Sci. Conf. 2nd*, pp. 1989-2001, 1971), which demonstrate an essentially continuous exponential growth in the cumulative mass distribution in this size range, and continuing for diameters of several hundred microns. This feature is likely attributable to the aspiration efficiency of the dry, gas-phase dispersal techniques used both here and by Rawles, et al. Corrections can be obtained for both techniques, but require somewhat labor intensive calibration procedures. For sizes below 1 μm, this correction can be reasonably neglected.

Similarly, corrections are involved at the upper size range of the SMPS data, and the lower size range of the APS data. The former relates to the penetration efficiency vs. size of the SMPS input impactor, and the relationship of this feature to multiple charge corrections that are also performed. Corrections for the APS arise from increasing deposition losses in the input nozzle with decreasing particle diameter. Again, both corrections can be accurately implemented, but require careful calibration procedures. The data shown here is a composite of lognormal best fits to the individual APS and SMPS data, such that these corrections introduce uncertainty into the width of the observed PSD, and could conceivably mask finer subtleties, e.g. a slight split of dual modality in the peak itself.