PARTICLE SIZE DISTRIBUTION OF LUNAR HIGHLAND DUST AND PREPARATION FOR TOXICITY STUDIES. D.W. Schnare, Y. Liu, B. Eimer, and L.A. Taylor, Planetary Geosciences Institute, Dept. of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN, 37996 (dschnare@utk.edu).

Introduction: The ubiquitous lunar dust is the <20 µm size fraction that makes up ~20 wt % of the lunar soil. It consists mostly of sharp, irregular-shaped, impact-produced glass. Nanophase metallic iron particles is present within the impact-generated glass and in thin silics-glass rims on most grains in a mature soil. This np-Fe imparts an unusual magnetic susceptibility and ferromagnetism to the soil [1]. Due to the extreme dryness of the Moon, this dust electrostatically adheres to spacesuits and equipment, adding to its deleterious nature and its ability to interfere with mechanized devices. In addition, this dust is thought capable of producing many adverse physiological effects in human respiratory systems. In particular, particles <3 µm in size can readily remain in the lungs, where they can cause fibrosis. Indeed, particles <100 nm, which are abundant in lunar dust, are likely to enter directly into the bloodstream [2].

In order to create dust abatement strategies and procedures, studies have been conducted on various properties of the dust, including its particle size distribution (PSD), magnetic susceptibility, and electrostatic interactions. Supplemental to these studies, a need to characterize the physiological effects on humans who come into contact with the lunar dust has led to studies of its particle morphology and toxicological effects [3]. For these studies, it is important that the samples used for exposure are equivalent to the material that the astronauts may actually breathe, i.e., the < 3 µm fraction. Obtaining this fraction for study using no liquids (i.e., dry) was a main goal behind the creation of the dry-aerosol-impactor size-separator described herein.

The use of a liquid would wash finer particles from the larger grains and thus, alter the morphology and the size distribution. Lunar samples are precious and of limited quantity. This size-separating apparatus only uses a small amount of the sample to be analyzed (grams) and does not require the use of a liquid.

Method: The dry-aerosol-impactor process we have developed involves an amount of sample (ideally ~5g) placed in a sample chamber attached to a shaker-table, with the system under constant air flow. As the sample is being shaken, the fine particles flow upward and through a series of tubes and impactors (Fig. 1). The larger particles collect at the corners of each impactor, a simple factor of fluid dynamics (Fig. 2). The finer particles flow onward into a membrane-filter where they are collected. After a given time interval, the filter is taken out and the sample recovered for particle-size determination. After obtaining the sized sample from this dry-separation it is further subjected to our standard particle size determination by an SEM technique [3].

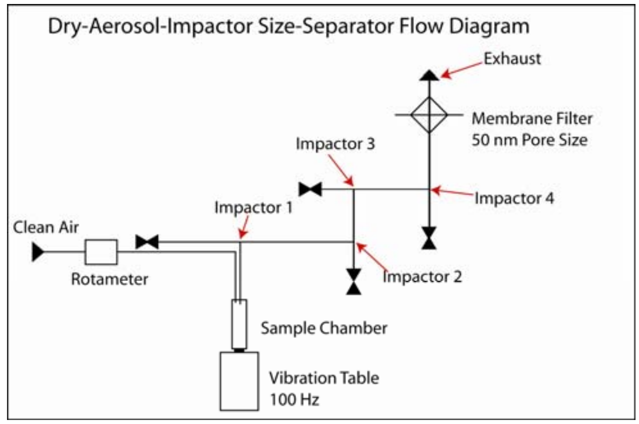

Figure 1. Flow diagram of the Dry-Aerosol-Impactor Size-Separator

The following lunar-highland soils were used in this study: 61501, I_s/FeO = 53, submature; 62241, I_s/FeO = 100, mature; and 64801 I_s/FeO = 71, mature [4]; along with lunar soil stimulant, JSC-1Avf. JSC-1Avf is the fine fraction (<20 µm) of a new batch of lunar simulant JSC-1.

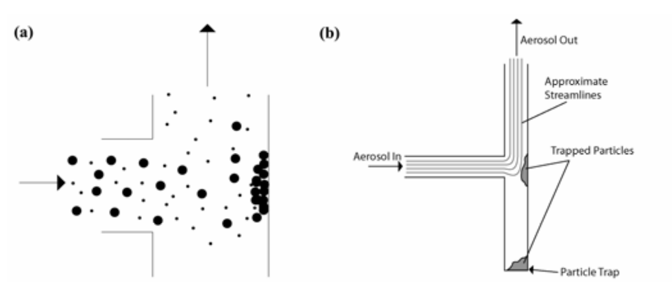

Figure 2. Diagrams of the impactor. (a) Illustration of particles flowing through an impactor. Large particles build up on the wall of the impactor. (b) Lines illustrate path of air flow through the impactor. As particles build up on the wall of the impactor they flake off into the 'Particle Trap'.

Results: This aerosol-impactor size-separator effectively removes particles larger than ~3-5µm (Figs. 3, 4). The majority of the particles (in numbers) are <3 µm. The lunar highland samples each display a peak at: 0.6-0.75 µm diameter for 61501; 0.55-0.75 µm for 62241; and ~0.75 µm for 64801. Simulant JSC1Avf has a large peak between 0.95 and 1.2 μm. The PSD peaks post-separation are slightly narrower than their broad pre-separation counterparts and at ~1 μm.

There is still a small fraction of >3 μm particles in the separated sample. Removal of large particles at the impactor is a statistical process: only a portion of the large particles can be removed. To decrease the content of these particles in a separated sample, more impactors may be required.

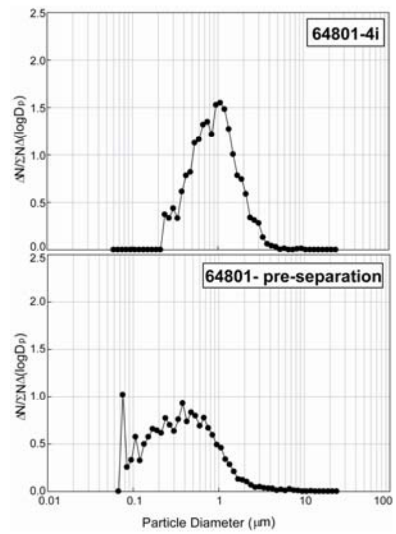

Figure 3. Particle Size Distribution of 64801 pre- and post-separator. The Y-axis is the normalized number per size bin.

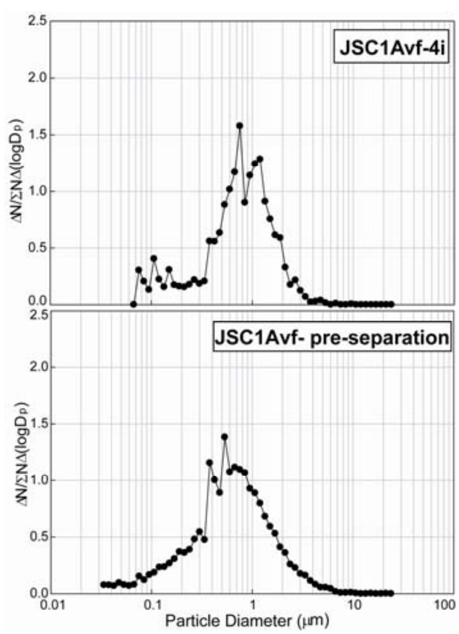

Figure 4. Particle Size Distribution of JSC1Avf pre- and post-separator.

Discussion: In all lunar soil samples, fine particles are attached to larger particles (Fig. 5). All previous sizing procedures have ulitized a fluid (i.e., freon, water). These fluids that facilitate the sieving actually wash fine particles off of their hosts. When large enough initial sample masses are used, the end result is a large increase in the number of fine particles in the obtained dust-sized fraction. In relation to physiological studies that are concerned with the respirable fraction of the dust, this large amount of fines is most certainly an overestimation compared to untreated lunar dust. During respiration, large numbers of these fine particles are likely to stay attached to their larger hosts, and be removed in the esophagus by cilia, before they enter the lung. Our device is air-powered to help counter this effect.

During the sample preparation for the SEM work, a surfactant solution and an ultrasonicator are used to disperse the particles to make the PSD determination possible. Throughout this process it is possible that some fine adhering particles are dislodged from their hosts. If this process is 100% effective, the PSD of the processed samples would be a maximum measurement of the amount of fine material in dust. This maximum would be one end member in the spectrum of respirable particles.

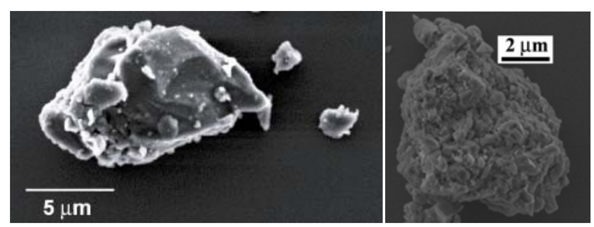

Figure 5. SEM image of 64801

Summary: Three lunar highland soils were dry-sieved by the dry-aerosol-impactor size-separator down to <3-5 um, verified by their PSDs, which were obtained by SEM imaging and digital picture analysis. The dust samples produced by the size-separator likely represent the maximum end member in a spectrum of respirable lunar particles. Samples produced by this method are quite useful in studies on the toxicological and physiological affects of lunar dust inhalation. In addition the PSDs of the fine fractions of the samples further emphasize that dust abatement strategies must deal with particles ranging from numbers of microns to a few nanometers in scale.

References: [1] Taylor L.A., Schmitt H.H., Carrier W.D., and Nagawa M. (2005) *AIAA-1st Space Explor. Conf.*, CD-ROM, 2005-2501; [2] Park J. S., Liu Y., Kihm K. D., and Taylor L.A., (2007) *Journ. of Aerospace Engineering (In Press)*; [3] Liu, Y., Park, J.S., Schnare D.W., Hill, E., and Taylor, L.A., (2007) *Journ. of Aerospace Engineering (In Press);* [4] Handbook of Lunar Soils (1983)