DUST MITIGATION: LUNAR AIR FILTRATION WITH A PERMANENT-MAGNET SYSTEM (LAF-PMS). B. C. Eimer and L. A. Taylor, Planetary Geosciences Institute, Dept. of Earth & Planetary Sciences, University of Tennessee, Knoxville, TN 37996, (lataylor@utk.edu).

In returning to the Moon, we must address many of the problems faced by the original Apollo astronauts. Major among these is the control of the fine dust (<20 µm) that makes up a large portion of the lunar surface (~20 wt%). This ubiquitous, clinging, sharp, abrasive, glassy dust caused a plethora of problems with seals, abrasion, and coatings, in addition to possible health problems, including 'lunar dust hay-fever' and long-term effects with the astronauts [1]. It is, therefore, critical that adequate filtration systems be used on the Moon in any pressurized locations to remove this dust from the air. While HEPA filters alone are able to accomplish much of this, the huge quantities of dust will quickly fill-up and clog them. Adding additional stages to remove the bulk of the suspended particles, greatly increases the lifespan and efficiency of the system. Using the unique magnetic properties of the lunar regolith, due to abundant nanophase metallic Fe [1-2], it is possible to create a system that uses magnetic fields to pull suspended particles out of the air. This study presents the basic principles and design for the construction of a filter, applying magnetic fields, which can be cleaned and reused with minimal power consumption.

The Lunar Soil Magnetic Collector (LSMAC) has been proposed to collect and transport the lunar regolith, utilizing the magnetic property of the lunar regolith [3]. The LSMAC is able to collect regolith without generating large amounts of suspended dust that would be, otherwise, 'kicked up' using conventional methods. However, even using the LSMAC to mitigate the dust that is suspended above the lunar surface, contamination of any pressurized module is inevitable and will be a persistent problem for any human presence on the moon. To reduce the health threat to anything living in these locations, it is necessary to have an air filtration system that is able to effectively remove particulate contaminants from the air. This will require a multi-stage system to increase the overall efficiency (Figure 1), and presents another opportunity for the magnetic properties of the lunar regolith to be used.

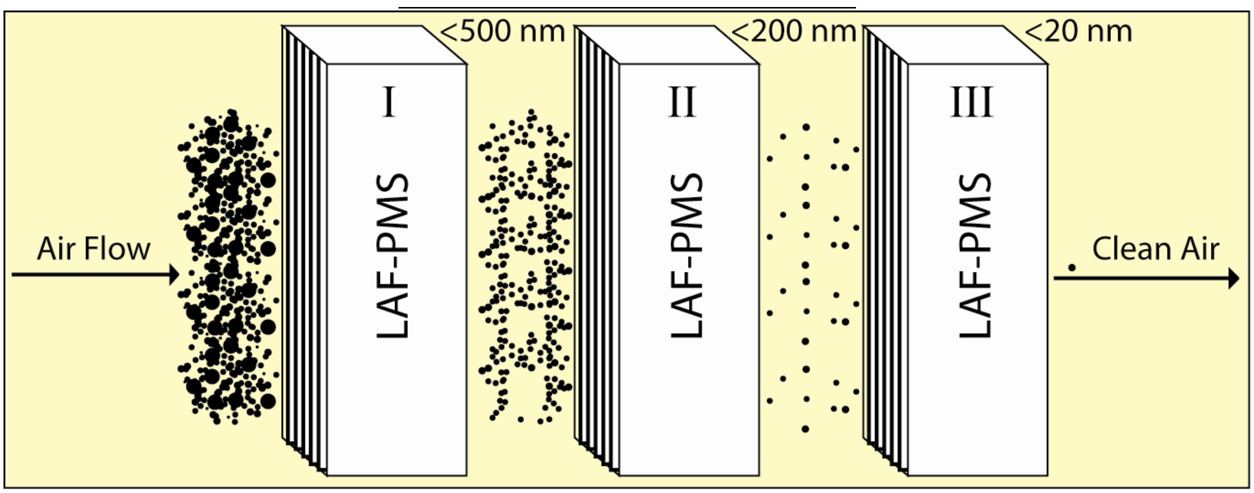

Figure 1. Multi-stage filtration system for use in a lunar habitat. Air filters that are reusable should be used to remove the majority of the dust particles - e.g., LAF-PMS. HEPA and electrostatic filters may not be necessary.

The Lunar Air Filtration with a Permanent-Magnet System – LAF-PMS – uses magnetic fields to attract particles out of the air. From fundamental electromagnetic theory, it is known that the force on a ferromagnetic particle due to a magnetic field is proportional to the gradient (change) of the field at the particle. Therefore, large field gradients are needed to trap the lunar dust within the filter. Using electromagnets, as in the case of the LSMAC, is not energy efficient due to the field strength required and the long duration that the fields would have to be on. Instead, it is more advantageous to use strong permanent magnets to generate the needed fields, requiring energy only to destroy the gradients to allow for cleaning.

To achieve the large field gradients needed for the LAF-PMS with permanent magnets, much care must be taken in choosing a layout to prevent canceled, wasted, or stray magnetic fields. By placing opposite poles of two long permanent magnets close together, a region with large field gradients is formed around the resulting gap (Figure 2 Insert). This concept has been used, by Urbach et al., previously on the nano-scale to attract paramagnetic gas particles; however, this concept is fundamental to magnetic fields and is independent of scale [4]. The technical challenge of this design is to incorporate the ability to destroy the gradients, reversibility, and on command. This can be accomplished by either: (1) changing the susceptibility of the material or (2) by generating a independent flux, within the gap between the magnets.

The LAF-PMS is made up of a series of plates of magnets that are arranged in rows with spaces between them (Figure 2). When the filter is 'on', the material between the magnets is paramagnetic and, therefore, has no effect on the magnetic fields. Air passes on both sides of each plate with particles being attracted to each gap. Turning 'off' the LAF-PMS for cleaning involves the simple exchange of the material between the magnets, i.e. movement of the plastic partitions. If a soft magnet (i.e., Fe) is inserted into these gaps, the gradient between the magnets disappears, and the trapped dust is freed. Cleaning can then be performed by agitation or wiping. The filter is then reactivated by pulling the Fe out from between the magnets, i.e. returning the plastic partitions to their original positions, thereby restoring the localized, intense fields.

It is of utmost importance that the health and well-being of any lunar pioneer be protected from every known danger. The dust of the moon is a danger that could threaten to severely restrict the health of these explorers. Therefore, it is vital to design safety equipment that is reliable, reusable, and efficient. The LAF-PMS fits nicely into this model, by using the unique properties of the lunar dust as an asset to solve a liability.

References: [1] Taylor, L.A., Schmitt, H.H., Carrier, W.D., III, and Nakagawa, N., 2005, *AIAA, 1st Space Explor. Conf.*, Orlando, FL, CD-ROM; [2] Taylor, L.A., and T. Meek, 2005, *Jour. Aerospace Engr.* **18,** 188-196; [3] Taylor, L.A., and B.C. Eimer, 2006, *Space Resources Roundtable VII*; [4] Urbach, A.R., J.C. Love, M.G. Prentiss, and G.M. Whitesides, 2003, *J. Am. Chem. Soc.* **125**, 12704-12705.

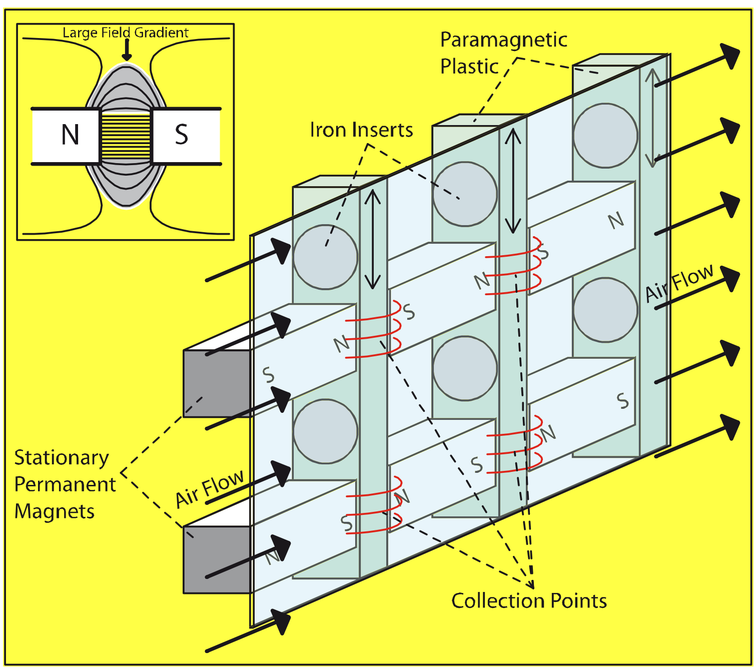

Figure 2. Schematics of the LAF-PMS. Plastic columns slide vertically, indicated by the fine arrows. To turn the filter off, the iron inserts in the plastic column are slid into the gap between the magnets. Magnetic field gradients are shown by representative flux lines (red curves). These are the collection points for ferromagnetic dust. Insert: Sketch of the flux lines between two long magnets. Change in density of field lines indicates a gradient in the field. Shaded area indicates area of large gradient where magnetic particles would be trapped.