LUNAR REGOLITH, SOIL, AND DUST MOVER ON THE MOON

Lawrence A. Taylor and Benjamin Eimer; lataylor@utk.edu, Planetary Geosciences Institute, Dept. of Earth & Planetary Sciences, University of Tennessee, Knoxville, TN 37996.

Returning humans to the Moon in the near-future will involve many considerations, designs, and engineering projects for exploration and ISRU activities. One factor common to all activities on the Moon is the ever-present, sharp, abrasive, glassy dust – the <20 µm portion of the lunar soil consisting of ~20 wt% of the soil. Various ISRU activities will entail movement of the lunar regolith, but conventional means will launch a large portion of dust that will numerous problems as it falls back covering such installations as solar cells, for example. The finest portions remain suspended in electrostatic levitation around the Moon – making for lots of consternation by any astronomers. But, can this dust portion of the soil be kept from having such deleterious effects? This is the subject of our study.

The lunar regolith contains many of the answers to reestablishing us on the Moon. Because of the presence of nanophase metallic Fe (as in a Fe nail) in the impact-produced glass, this "well-graded" soil can be sintered and melted into building blocks, antenna dishes, roads, etc. with the application of microwaves [1]. The surfaces of the dust contain solar-wind particles, providing a potential source of hydrogen for water and fuel. However, there is a down-side to the fine portion of the soil, the DUST. It is prone to being 'kicked up' by most activities on the surface of the Moon, thereby creating a plethora of problems, many experienced during the Apollo Missions, as discussed by Taylor et al. [2]. Therefore, it is imperative to develop a method of handling and collecting lunar regolith that mitigates against the possibility of stirring too much dust into the lunar "atmosphere."

We have devised a potential scheme to mitigate the dust problem utilizing its ferromagnetic pro-perties, due to the presence of nanophase metallic Fe in the ~40-50% impact glass of the lunar soil. The presence of 80-90% glass in the dust makes this portion of the soil totally capable of being attracted by a simple magnet [2]. The presence of this np-Fe bearing glass in larger agglutinates also renders a magnetic susceptibility to the larger grain-sized soil particles. It should be possible to effectively "suck-up" the regolith using magnetic fields. This can be done in a similar fashion to the way maglev trains and coil guns (or gauss weapons) work. These two developing technologies *use consecutive electro-magnets to pull an object along*. The largest advantage of these technologies is that there are no moving parts in the device. Most importantly, such an attracting systems applied to the Moon would not only pull the soil along, but effectively capture the dust as well.

The operation of this 'coil vacuum' is conceptually simple (Fig. 1). This device consists of a series of wound coils individually powered to generate magnetic fields. Soil is picked up by a 'nose coil' and pulled into the center of the coil. As this moving soil approaches this first coil, the coil is powered down, and the next coil in the sequence is powered up and attracts the particles of soil further into the tube. As the soil approaches this second coil, it too is powered down, and the next coil in the sequence is powered up to tractor the soil further down the line. This process of turning coils on and off continues in a "caterpillar / millipede effect" moving the soil particles along this electronic-conveyor belt.

Conceptually a lunar surface-mining operation might use this device to gather and transport soil (+dust) across great distances to processing plants. One possibility is to have a 'Trunk Line' that is capable of large magnetic fields and moving large amounts of material with several feeder lines into it (Figure 2). The feeder lines would branch off of the Trunk Line pulling in material from the surrounding area. This allows for several areas to be excavated simultaneously, and as the regolith is exhausted in one large area, the Trunk Line can be extended to new areas.

To make the "Lunar Magnetic-Soil Vacuum Cleaner" (LMSVC) and the 'coil vacuum' scheme a reality requires several issues to be overcome. First, the magnetic fields must be sufficiently strong as to attract the soil from a reasonable distance and accelerate it to a speed sufficient to carry it to the next coil through momentum. In the case of the Moon, this is eased somewhat by both the absence of atmosphere and the $1/6^{th}$ G gravity on the Moon (lighter to pick up vertically, and less drop in horizontal transport). Second, it will be necessary to determine the on-off timing needed to energize and relax consecutive rings, in order to keep a continuous flow of soil through the tube. The feedback-loop timing will maintain efficiency.

The dust of the Moon is one of the major environmental challenges that we face in returning to the lunar surface. However, this dust can be of great use in making life on the Moon possible. It is a matter of perspective and attitude that can change this pest and curse into an invaluable tool and resource. By using properties that are inherent in the lunar soil, it is possible to

eliminate the potential hazard of having this dust suspended above the surface.

References: **[1]** Taylor, L.A., and T. Meek, 2005, Jour. Aerospace Engr. **18,** 188-196; **[2]** Taylor, L.A., Schmitt, H.H., Carrier, W.D., III, and Nakagawa, N., 2005, AIAA, 1st Space Explor. Conf., Orlando, FL, CD-ROM

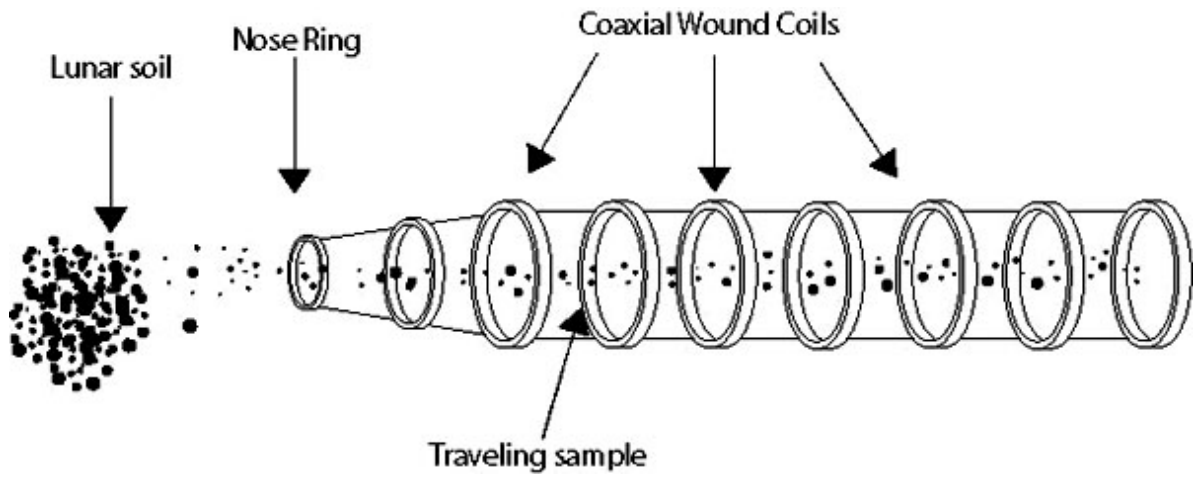

Figure 1. Diagram of our "Lunar Magnetic-Soil Vacuum Cleaner" illustrating a 'coil vacuum'. Coaxial rings are sequentially powered up and down in a rippling effect to move ferromagnetic lunar soil to the right.

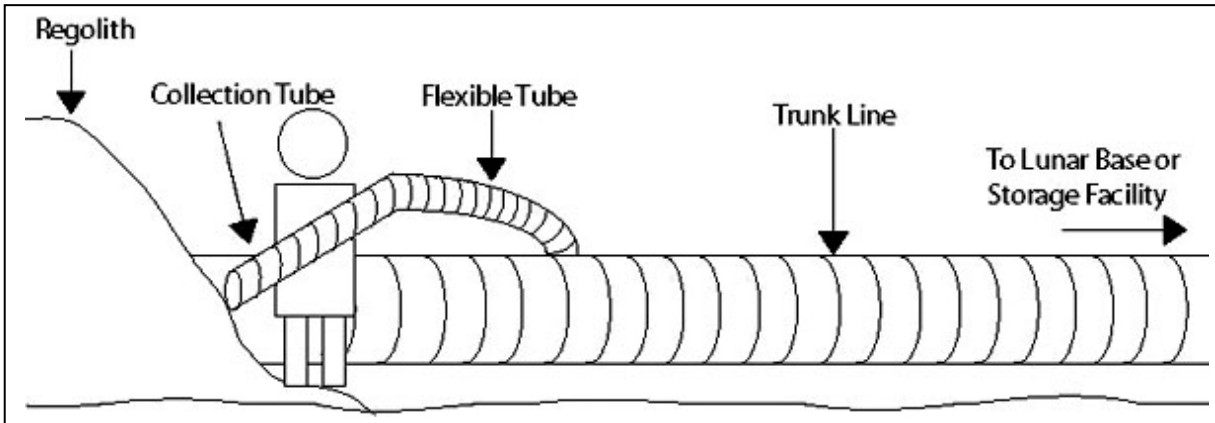

Figure 2. Conceptual drawing of possible method of collecting lunar soil using the "Magnetic-Soil Vacuum Cleaner" (LMSVC) with the concept of a 'coil vacuum'. The astronaut/robot uses a slightly flexible coil 'sucker tube' to collect soil, which is in turn fed into a hard mounted "Trunk Line" that is capable of higher flow rates and is transported to be used at a relatively stationary facility. Multiple collection branches would feed into one trunk line.