THE LUNAR DUST PROBLEM: A POSSIBLE REMEDY

Lawrence A. Taylor, Planetary Geosciences Institute, University of Tennessee, TN 37996; lataylor@utk.edu.

Introduction: Those of us who were around during the early Apollo days know well about the "Gold Dust Theory," that cost NASA beaucoup dollars. And the electrostatic fluffiness of the lunar soil was not a problem to landing on the Moon, but may contributed to the dust that was observed to cling to the astronauts' suits, as well as to the "rock boxes" such that they all leaked. However, the fine-grain nature (50 wt% = <50 μm) of the lunar soil, in the presence of the 1/6th gravity of the Moon, with the potential for extensive beneficiation of lunar soil has the 'EPA' and astronomers upset. They envision huge clouds of dust flying around the Moon, covering telescopes and solar cells. In addition, the large glass contents (up to 100%) of lunar soil makes the abrasive properties of the dust a great concern for any moving parts. However, a possible solution to many of these fears involves use of the magnetic properties of the lunar soil [1] and results of recent studies of the Lunar Soil Characterization Consortium (LSCC) [2-7].

Formation of Lunar Soil: The major factor in the formation of lunar soil involves micrometeorite impacts. Larger particles are comminuted to finer and silicate melt welds together soil grains into glassy aggregates called agglutinates. These two competing processes complicate the formational characteristics of the soil. Recently, we have become aware of yet another set of processes that significantly affect lunar soils. This is the formation of surface-correlated *"nanophase Fe^o"(4-33 nm)*, resulting from impact-induced vaporization and deposition of Fe-, Al-, and Si-rich patinas on all soil particles [8-12], as well as sputter-deposited contributions [13]. The average grain size of this nanophase Fe^o is substantially less that that in agglutinitic glass such that it causes the major portion of the space weathering effects to reflectance spectra [5-7; 9-12; 14-15].

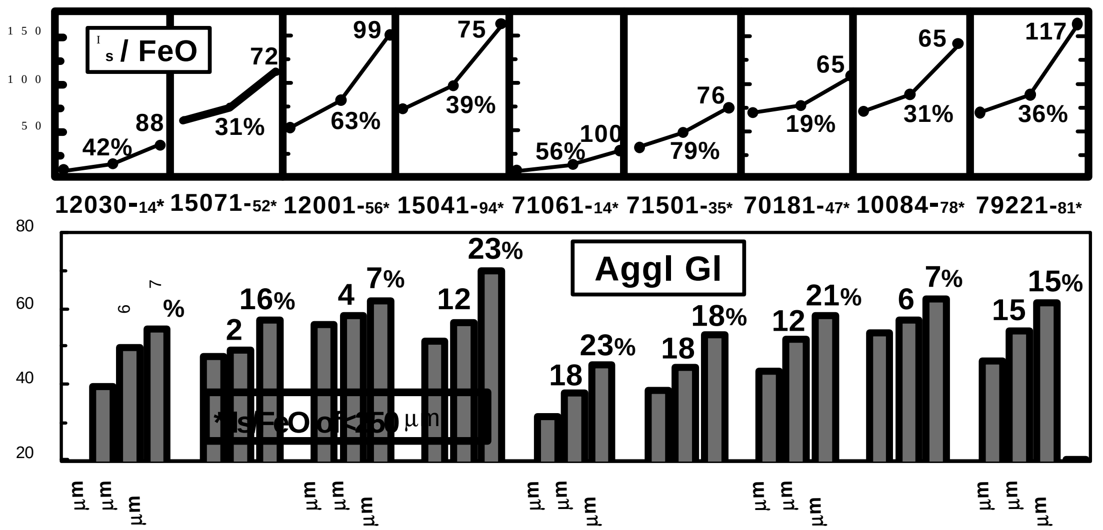
Agglutinitic Glass versus Grain Size and Maturity: The data shown in Figure 1 were derived from studies by the Lunar Soil Characterization Consortium [5-7; 9-12]. In a given mare soil, <u>*the abundances of agglutinitic glass increase significantly with decreasing grain size*</u>. In spite of the different abundances of agglutinitic glass in the different size fractions, <u>*the average composition of the agglutinitic glass for each grain size of a given soil is similar*</u>, as shown in Taylor et al. [7].

I_s/FeO versus Grain Size and Maturity: A comparison of soils of different maturities, as measured by *I_s/FeO* [16], shows that for any given grain size, *the amount of agglutinitic glass increases with maturity.* This is a direct reflection of the duration of surface exposure of a soil to micro-meteorite gardening, with its space-weathering effects. Therefore, as shown in Figure 1 by the values after the sample numbers (e.g., 71061-14) 12030, the *I_s/FeO values of soils increase as a function of maturity* [16]. As also shown in Fig. 1, within a given soil, <u>*the I_s /FeO values increase with decreasing grain size.*</u> In Figure 1, the percentage increase, in I_s/FeO and agglutinitic glass, from the larger grain size to the next smaller size fraction, is given above the respective sizes. An increase of 100% for I_s/FeO indicates that the amount of nanophase Fe^0 has doubled, relative to the total Fe. Notice that <u>*with a decrease in grain size, the change in agglutinitic glass content is relatively small compared with the change in I_s/FeO*</u>***.*** This logically leads to the conclusion that <u>*the large increase in I_s/FeO is direct proof of the presence of another source of nanophase Fe^0, in addition to the agglutinitic glass*</u>.

The thesis on vapor-deposited patinas [8] has also found supporting evidence in several subsequent studies [4-7; 9-12]. ***The presence of nanophase Fe^0 in the vapor-deposited patinas (rims) on virtually all grains of a mature soil provides an additional and abundant source for the greatly increased I_s/FeO values.*** For the same masses, <u>*the surface area of the soils increases by a factor of 4, as the grain size decreases by 50%.*</u> If the increase in I_s/FeO, that is attributable to the minor increase in agglutinitic glass, is accounted for in each change in grain size, the 'residual' is the possible surface-correlated I_s/FeO contribution. On average, there is still a 2-5X increase in I_s/FeO between size fractions, whereas a decrease in grain size of 50%, increases the surface area by 4X (i.e., 400%). Therefore, as a first approximation, <u>*the increase in I_s/FeO of 2-5X correlates well with the predicted 4X increase in particle surface area (i.e., surface-bound nanophase Fe^0.*</u>

Magnetic Separation of Lunar Soil Particles: Taylor and Oder [1] performed studies on lunar soils in order to determine the optimum conditions for the beneficiation of soil components for in-situ resource utilization (ISRU) at a lunar base. Using a Frantz Isodynamic Separator, specifically calibrated for mag-

Figure 1. Comparison of Is/FeO Values and Agglutinate Glass Contents for Apollo Mare Soils.



netic susceptibility measurements, they studied various size fractions of several mare and highland soils. They were able to successfully beneficiate the soil particles with decreasing efficiency as grain size decreased, down to 45-20 µm. However, with sizes <20 µm, they determined that magnetic separation of particles was not feasible. It appeared that 'clumping' of these fine-sized grains was responsible. It was apparent that this size fraction behaved as if virtually all the particles had relatively higher magnetic susceptibilities than the coarser particles. In retrospect, this behavior is now explainable in that each of these fine grains contains a surface patina of ferromagnetic nanophase Fe^0, thereby increasing its magnetism.

Recent experimentation by the author with the <10 µm fraction of mature hi-Ti mare soil 79221 has shown that a small hand magnet will easily attract practically all the grains, even those that are plagioclase. This is the basis for a possible solution to the "lunar dust problem."

Solution: The finest grain sizes of lunar soils have higher magnetic susceptibilities than their obvious mineralogy would seem to predict [1]. This is due to the presence of ferromagnetic Fe^0 on the surfaces of most soil grains. This added property, a product of space weathering, is especially effective for the finest grain sizes where the surface/volume ration is largest. It is hereby proposed that a "magnetic sweeper" would clean most surfaces of the fine grains of lunar soil that may cover various installations. Even "magnetic filters" could prove invaluable for improving the healthiness of breathing air, a non-consequential problem.

References: [1] Taylor & Oder, 1990, SPACE 1990 Proc., 143; [2] Taylor et al., 1998, LPI-958, New Views, 71; [3] Pieters & Taylor, 1998, New Views, LPI-958, 6; [4] Taylor et al., 1998, LPSC 29, LPI-CD 1160; [5] Taylor et al., 2000, SPACE 2000 Proc.; [6] Pieters et al., MPS, in press; [7] Taylor et al., MPS, in press; [8] Keller & McKay, 1997, GCA 61, 2331; [9] Taylor et al., 1999, LPSC 30, LPI-CD 1859; [10] Taylor et al., 1999, New Views of the Moon II, LPI; [11] Taylor et al., 2000, LPSC 31, LPI-CD 1842; [12] Taylor et al., 2000, LPSC 31, LPI-CD 1697; [13] Bernatowicz et al., 1994, LPSC XXV, 105; [14] Keller et al., 1999, LPSC 31, LPI-CD 1820; [15] Keller et al., 2000, LPSC 31, LPI-CD 1655; [16] Morris, 1976, LPSC 7, 315.