

INTEGRATION OF THE CHEMICAL AND MINERALOGICAL CHARACTERISTICS OF LUNAR SOILS WITH REFLECTANCE SPECTROSCOPY - Lawrence A. Taylor¹, Carlé Pieters², Richard V. Morris³, Lindsay P. Keller⁴, David S. McKay³, Allan Patchen¹, & Susan Wentworth³; **1** = Planetary Geosciences Institute, Univ. of Tennessee, Knoxville, TN 37996, e-mail = lataylor@utk.edu; **2** = Geological Sci., Brown Univ., Providence, RI 02912; **3** = Planet. Explor. Div., SN, Johnson Space Center, Houston, TX 77058; **4** = MVA, Inc., Oakbrook Pkwy., Norcross, GA 30093.

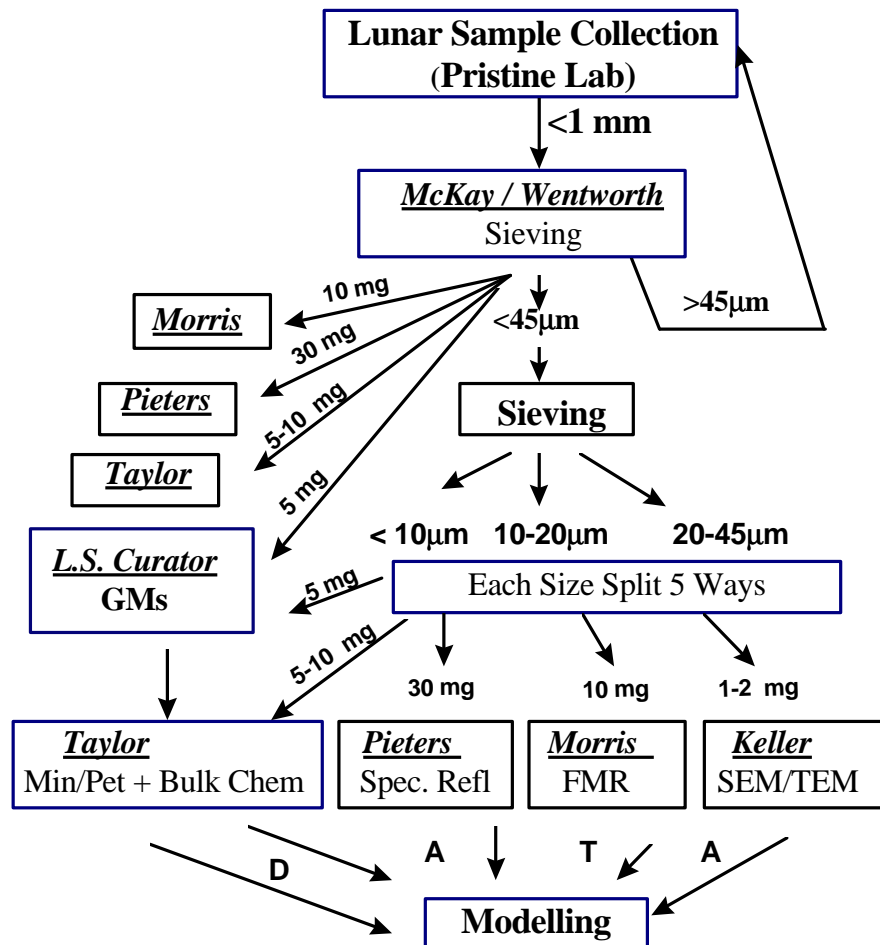
The foundation for remote chemical and mineralogical analyses lies in the physics underlying optical absorption and the linking of spectral properties of materials measured in the laboratory to well-understood mineral species and their mixtures [1].

This is the overall premise underlying the organization of **Lunar Soil Characterization Consortium**. This abstract outlines the various endeavors of the current Consortium-member research teams led by: Larry Taylor, Carlé Pieters, Dick Morris, Lindsay Keller, and Dave McKay.

INTRODUCTION - It is not the rocks of a heavenly body that are observed by remote sensing, but the regolith, that may contain small pieces of rock but also

many other phases as well, (e.g., glass). This surficial material on airless bodies originated due to exposure to the environment of "space-weathering," with its major components of micro-meteorite impacts, solar-wind-implanted gases, and energetic particles. The major effects of this weathering include the formation of agglutinitic glass, nanophase iron, and vapor-deposited patinas on each soil particle. Collectively, these products have complicated the spectroscopic properties of the lunar regolith with the creation of three principal optical effects: 1) overall reduction of reflectance; 2) general attenuation of diagnostic absorption bands; and 3) development of a characteristic red-sloped continuum [e.g., 2].

It is imperative to fully understand the chemical,



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mineralogical, and physical nature of the regolith, particularly its finer fraction termed "soil", to understand the possible effects of "space weathering" upon remotely acquired data. *In order to make more direct and quantitative links between soil chemistry/mineralogy and spectral properties, we have initiated a program to: 1) obtain accurate characterization of the chemistry and petrography of lunar soils (in terms relevant to remote analyses), coupled with 2) measurement of precise reflectance spectra, with testing and use of appropriate analytical tools that identify and characterize individual mineral and glass components.* This study of our nearest, regolith-bearing body, the Moon, should act as "ground truth" for further probes of planetary and asteroidal surfaces.

Lunar Soils: As shown by Pieters et al. [3] and Fischer and Pieters [2,4], it is the finest size fractions of the bulk lunar soil that dominate the observed spectral signatures. Optically the 20-44 μm , 10-20 μm , and <10 μm size fractions are the most similar to the bulk soil [5]. However, the detailed petrographic and chemical properties of these finer fractions of lunar soils, most relevant for remote spectroscopy, are not well-characterized in terms of optically active phases. Therefore, modern techniques are required to characterize soil components, particularly with these fine-size fractions, with the accuracy needed for spectroscopic analyses. That is, in order to address such fundamental problems as the effects of space weathering, it is necessary to know the detailed volume percentages (and compositions) of the minerals and glasses of the lunar soils, modal data which presently do not exist in the literature. Armed with such data, it should be possible to effectively isolate spectral effects of space weathering from spectral properties related to mineral/glass chemistry.

For the mare soil portion of these endeavors, nine (9) mare soils were chosen from the four Apollo mare sites - Apollo 11, 12, 15, 17. These soils were chosen for their contrasting maturities, as reflected in their Is/FeO values [6]. Initially [7], we were inappropriately allocated "returned lunar soils" that had unacceptable degradation histories; however, our new allocation of soils comes from the "pristine lunar samples." All of the previous work on the degraded samples [7] was not in vain, however. Effects of Freon sieving produced spectral anomalies with the <10 μm fraction of soil, as originally observed by Fischer & Pieters [2]. Therefore, dry ultrasonic sieving with an Sonic Sifter[®] was utilized, but this also produced artifacts due to "in situ weathering" by the sieving process. The effects of both Freon sieving and ultrasonic sieving are discussed in an accompanying abstract by

Noble et al. [this vol.]. After considerable experimentation, triply-distilled water was utilized for the present soils.

Consortium Member Tasks: As shown by the flow sheet in Fig.1, we have established a systematic approach to the processing of the mare soils. The soils are sieved by Sue Wentworth, under the supervision of **Dave McKay**. The Lunar Sample Curator, **Gary Lofgren**, and his staff, play a critical role in the handling and distribution of the soil splits and the production of excellent-quality grain mounts. **Larry Taylor's team** receives a small quantity of each soil fraction, for fused-bead major-element chemistry. They also receive polished grain mounts of each size split for the complete characterization of the modal amount of the minerals and glasses, as well as the average composition of each phase. This is performed with the electron microprobe using digital X-ray imaging analyses, as discussed in Taylor et al. [8]. **Dick Morris** receives subsamples of separates and will measure the Is values of the nanophase Fe component by FerroMagnetic Resonance. **Lindsay Keller** receives a smidgen of each soil split for examination, particularly of the <10 μm fraction. The findings by his team [9, 10] of the major role of vapor-deposited patinas on most soil particles, and containing nanophase Fe, is a major break-through in the understanding the nature of the "amorphous coatings" that form these rinds. **Carlé Pieters**, students, and colleagues will perform the spectral measurements using the Brown University RELAB. Carlé's team will also play a major and critical role in the modelling of the spectra based upon the chemical and mineralogical characterization data obtained by Taylor, Morris, and Lindsay. As this study proceeds, our characterization and reflectance data will become available for all interested parties.

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