

**LSCC APOLLO AND LUNA SOIL ANALYSES: UPDATE OF SOIL EVOLUTION MODEL.** C. M. Pieters<sup>1</sup>, L.A. Taylor<sup>2</sup>, D. S. McKay<sup>3</sup>, R. V. Morris<sup>3</sup>, L.P. Keller<sup>3</sup>, <sup>1</sup>Dept. Geological Sciences, Brown University, Providence, RI 02912, <sup>2</sup>Planetary Geoscience Institute, University Tennessee, Knoxville, TN, <sup>3</sup>Code SN, JSC Houston, TX. (Carle\_Pieters@brown.edu)

The Lunar Soil Characterization Consortium (LSCC) has obtained samples of Luna 16, 20 and 24 soils. Although these particular samples encountered contamination during processing, preliminary results are consistent with previous integrated analyses and expand the soil data to three additional sites.

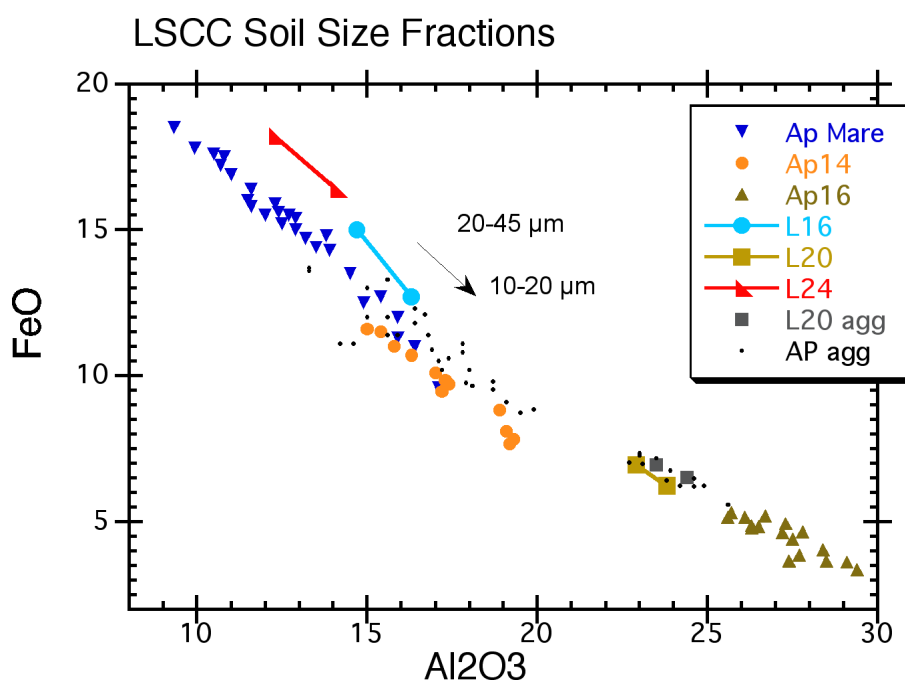
**Background:** Detailed modal abundances and chemistry of the minerals and glasses in representative Apollo mare and highland soils have been measured in a coordinated manner with modern instruments and are almost complete [1, 2, 3]. These Lunar Soil Characterization Consortium (LSCC) studies confirmed that the proportion of agglutinates (as measured by agglutinitic glass content) increases with increasing exposure to the space environment, but identified nanophase reduced iron (npFe<sup>0</sup>) deposited on the surface of grains as the principal carrier of optical alteration effects [1, 4, 5]. For an individual soil, the LSCC studies also showed that the proportion of agglutinitic glass as well as the feldspathic component as seen in the bulk chemistry increases systematically with decreasing particle size for all soil types.

Our original interpretations of LSCC data for mare soils suggested fusion of the (feldspathic) finest fraction (F<sup>3</sup>) [6] played the dominant role in soil evolution,

in particular formation of agglutinitic glass [1]. Subsequent LSCC data for Apollo 14 and Apollo 16 soils, however, were inconsistent with the F<sup>3</sup> model; the average composition of agglutinitic glass from Apollo 16 separates is in fact *less* feldspathic than the bulk soil separate from which it was derived.

We have recently presented a revised model of soil evolution constrained by the full suite of LSCC data for Apollo lunar soils [7]. Favored simple models for glass formation, such as the F<sup>3</sup> model, are discounted, but the data indicate that lateral mare-highland mixing and selective melting of soil phases are both significant parts of soil evolution. We proposed mare-highland mixing of a significant glass component along with a preferential melting sequence for agglutinitic glass formation of: glass > plagioclase > pyroxene >> ilmenite.

**Luna Soils.** We have been eager to obtain additional data to test this new soil evolution model. Herein, we present preliminary data for a few Luna soils here. The soils were graciously provided by the Vernadsky Institute of the Russian Academy of Sciences. Shown in Figure 1 are the compositional trends of Al<sub>2</sub>O<sub>3</sub> and FeO for all Apollo and Luna soil data measured to date.



**Figure 1.** Compositional trends for all LSCC soil data. The Apollo data include three size fractions for each soil: 45-20, 20-10, and <10  $\mu$ m. Only the larger two size fractions are shown for Luna soils. Luna 20 data overlay Apollo 16 agglutinitic glasses.

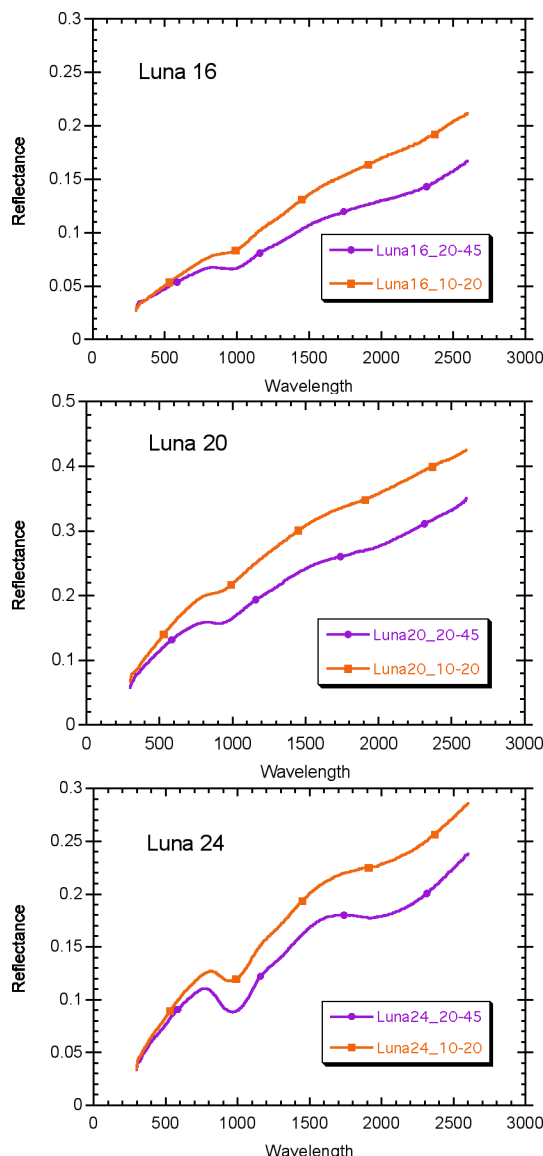
Apollo Mare soils include:  
10084, 12001, 12030,  
15041, 15071, 71061,  
71501, 70181, 79220

Apollo 14 soils include:  
14141, 14163, 14260,  
14259

Apollo 16 soils include:  
61141, 61221, 62331,  
64801, 67461, 67481

The small size of the Luna samples allocated precluded separation of a bulk <45  $\mu$ m sample. Unfortunately, the preparation of size fractions for the Luna soils encountered difficulties and the finest size fraction, <10  $\mu$ m, was heavily contaminated (the source is being investigated). Nevertheless, the two larger size fractions (45-20, 20-10  $\mu$ m) appear normal.

Bidirectional reflectance spectra of these new samples are shown in Figure 2. Mineral analyses of these size separates are under way.



**Figure 2.** Bidirectional reflectance spectra of size separates of Luna 16, 20, and 24 soils. Note the difference in scale for the brighter highland sample (Luna 20).

**Discussion.** The very small size of the Luna separates will make typical LSCC detailed analyses challenging. Although the compositional and maturity ( $I_s/FeO$ ) analyses for the suite of Luna samples have not yet been made, these preliminary data are encouraging. It is clear from Figure 1 that the new Luna data exhibit some of the compositional trends as a function of particle size that were observed for other sites. Specifically, the finer fractions all exhibit a more feldspathic composition (lower FeO, higher  $Al_2O_3$ ) than the larger size fractions. The overall character of the mare (Luna 16 and 24) and highland (Luna 20) spectra in Figure 2 are also consistent with their known properties, namely Luna 24 soil is relatively unweathered (immature) and exhibits prominent absorptions due to pyroxene.

Although the agglutinitic components have not yet been analyzed for the Luna mare soils, the limited data available for Luna 20 shown in Figure 1 is neutral in terms of our new soil evolution model. The relation of Luna 20 agglutinitic glass to the size fractions from which they were derived follows the pattern observed for Apollo 14 soils. It is the disparity of the pattern for the agglutinitic glass compositions relative to their host soil observed for mare soils and Apollo 16 soils that caused us to abandon the  $F^3$  model [see 7].

**Conclusions.** The preliminary new Luna data are consistent with similar analyses for LSCC Apollo data. When more complete, the coordinated analyses of Luna soils will add considerably to the value of the LSCC soil data. Although the new Luna data have not provided additional insight for our new soil evolution model, the combined Apollo data still strongly require both differential melting and lateral mixing processes.

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#### References:

- [1] Taylor et al., 2001, *JGR*, 106, (E11), 27,985-28,000.
- [2] Taylor et al., 2003a, *LPS XXXIV*, CD-ROM# 11774.
- [3] Taylor et al., 2003b *JGR*, in preparation.
- [4] Keller and McKay, 1997, *Geochim. Cosmochim. Acta*, 61, 2331,
- [5] Noble et al. 2001, *Meteorit. Planet. Sci.*, 36, 31-42
- [6] Papike et al., 1981, *Proc. Lunar Planet. Sci. 12th*, B, 409-420
- [7] Pieters C. M. and L. A. Taylor, 2003, *Geophys. Res. Lett.*, VOL. 30, NO. 20, 2048, doi:10.1029/2003GL018212,