LUNAR AGGLUTINATE GLASS COMPOSITIONS AND COMPARISON TO SOIL GRAIN-SIZE FRACTIONS. Anna E. Baker[1], Bradley L. Jolliff[1], Chanud N. Yasanayake[2], Brett W. Denevi[2], and Samuel J. Lawrence[3], [1]Dept. Earth and Planetary Sciences and McDonnell Center for the Space Sciences, Washington University in St. Louis, MO 63130; [2]Johns Hopkins Applied Physics Laboratory, Laurel, MD 20723; [3]NASA Johnson Space Center, Houston, TX 77058, USA. (annabaker@wustl.edu)

Introduction: When micrometeorites strike the surface of the Moon, small aggregates of mineral and lithic clasts are welded together by glass, forming particles called agglutinates. The details of their formation are important for understanding space weathering of airless bodies. Data from the Apollo missions demonstrated that lunar soil composition differs among grain-size fractions. According to the Fusion of the Finest Fraction (F^3) model [1,2], agglutinate glass compositions approach the composition of the finest fraction (<10 μm) of the soil in which they formed. The rationale is that smaller particles have higher surface-to-volume ratios and thus melt more efficiently. Subsequent studies provided support for the F^3 model [3,4]. As part of a study of the effect of agglutinates on soil reflectance spectra [5], we revisit the relationship between agglutinate glass composition and the soil grain size-separate compositions determined by [3,6]. Here, we report agglutinate glass compositions from eight Apollo regolith samples (Table 1) and compare the compositions with those of soil grain-size fractions determined by the Lunar Soil Characterization Consortium (LSCC) [3,6,7].

Methods: Agglutinates from all of the soils (except 14161 and 75082) were hand-picked from a sieved 125-250 μm grain-size fraction of each sample [5]. Agglutinates from samples 14161 and 75082 occur in thin sections used in past research.

Table 1. *Characteristics of the lunar samples. N is the number of agglutinates analyzed from each sample [maturity from 8,9].*

Sample	N=	Maturity (I_S/FeO)	Site Composition
14161	2	Submat. (57)	moderate-Fe nonmare
14259	9	Mature (85)	
15041	10	Mature (94)	low-Ti mare (basalt)
61141	9	Submat. (56)	low-Fe highlands
62231	11	Mature (91)	
67461	10	Immat. (25)	
75082	2	Submat. (40)	high-Ti mare (basalt)
79221	10	Mature (81)	

Agglutinate glass compositions were determined using an electron microprobe with an accelerating voltage of 15 kV and beam current of 25 nA. For each agglutinate, >10 spots were analyzed using a beam diameter ≤5 μm. We selected glassy spots that appeared homogeneous in backscattered electron (BSE) images and, where possible, were not directly adjacent to any clasts or vesicles. We eliminated outliers from the data, and then calculated the average glass composition of each agglutinate. We analyzed multiple agglutinates from each sample (see table), and the results from each were averaged to determine the mean composition of agglutinitic glass for each soil sample.

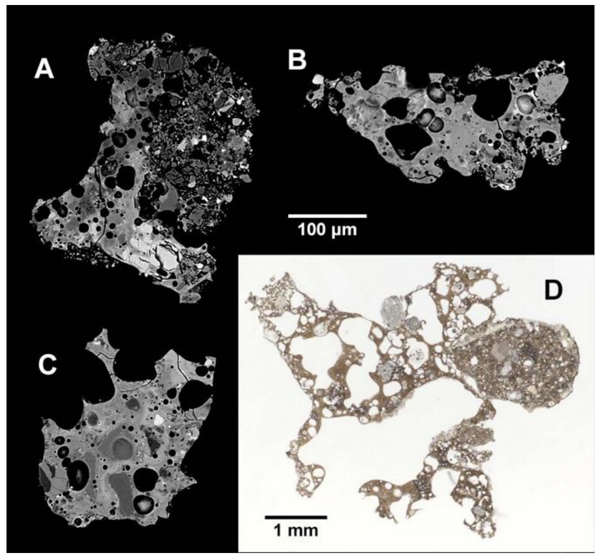

Figure 1. *A selection of agglutinate images made by (A-C) electron microprobe (BSE) and (D) optical microscope. A=61141 Agglutinate 3; B=14259 Ag. 4; C=14259 Ag. 7; D=14161,7101.*

Results: In the agglutinates we studied, glass that binds agglutinates makes up ~35% (ranges from ~20-50%) of the surface area exposed in polished grain mounts, according to preliminary results. As is typical, agglutinitic glass in our samples contains schlieren and regions of partial melt surrounding mineral and lithic clasts, but the more homogeneous-appearing areas in BSE images have fairly uniform compositions on the scale of our microbeam sampling.

Our results show that the average composition of agglutinitic glass is very similar to that of the <1 mm "bulk" soil in which the agglutinates occur (Fig. 2). Agglutinate glass is also similar to the <45 μm fraction, which broadly encompasses all the finer soils. Of the narrow grain-size fractions characterized by the LSCC (20-45, 10-20, and <10 μm), we find that agglutinate glass is most similar to the 10-20 μm soil. Figures 2-4 compare compositional data for the soils and agglutinates.

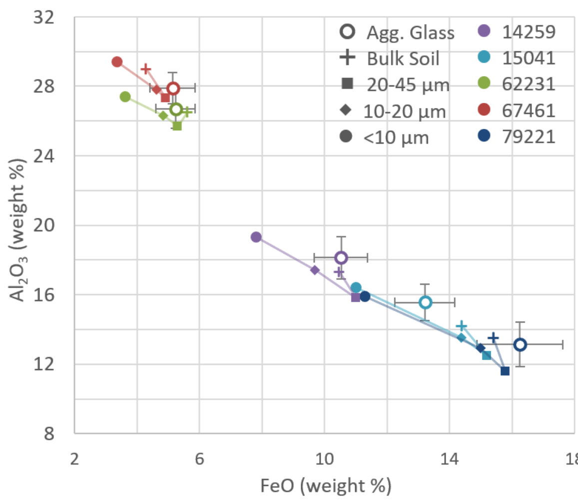

Figure 2. *Comparison of FeO and Al_2O_3 contents of bulk soil, soil grain-size fractions, and agglutinate glass for selected samples. Error bars show standard deviations of average agglutinate glass composition for the different agglutinates analyzed.*

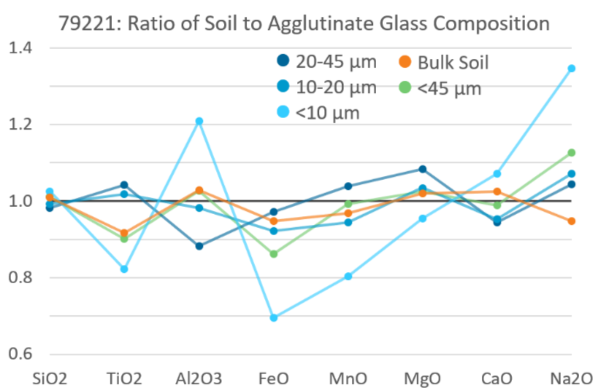

Figure 3. *Ratio of soil to agglutinate composition (in wt. % oxide) for different grain-size fractions of soil. The <10 µm fraction deviates the most, whereas the 10-20 µm and bulk <1 mm are most similar. This example (79221) is approximately representative of the other samples tested.*

Discussion: Careful analysis of the glass in our agglutinates shows that their compositions are very similar to that of the bulk (and <45 µm) soil in which they form. This relationship is consistent across the different soil types and compositions from the four Apollo sites. However, our results show that agglutinate glass does not match the composition of the finest fraction of soil (<10 µm) as predicted by the F^3 model.

Some similarities between agglutinate glass and the bulk soil may be partially explained by an amendment to the F^3 model offered by Basu et al. [4]. They proposed that agglutinate glass is the sum of the melts produced by (a) fusion of the finest fraction and (b) the micro-volume of the immediate target, which melts indiscriminately upon impact. However, in either the original or revised model, the glass should fall on a mixing line between the bulk soil and the finest fraction, but in several cases it does not (62231, 14259 in Fig. 2). Of the eight regolith samples examined, only one (15041) has an agglutinate glass composition similar to its <10 µm soil, and even in that case the glass falls about halfway between the <10 µm and bulk soils for all major elements.

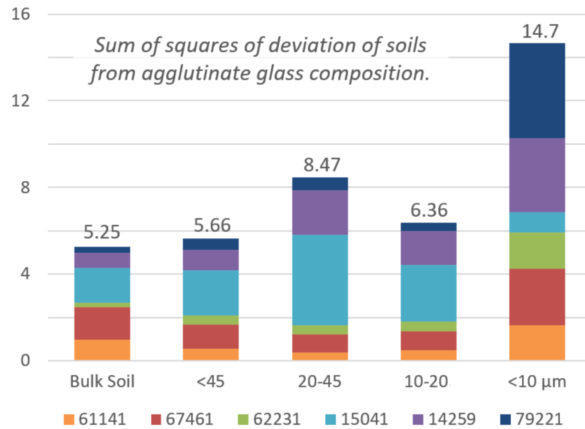

Figure 4. *The sums of squares of deviation (of differences in weight percent of oxides) divided by n, calculated for each of the grain-mounted samples and stacked by soil grain-size fraction. (Larger values indicate greater variation from agglutinate glass composition.)*

These results suggest that melting in micrometeorite impacts is not constrained to the <10 µm soil grains. The finest grains may melt more easily because of their high surface-to-volume ratios, but still make up only a small percentage of the total melt due to their low abundance in lunar soils (~10 wt. %) [10]. In future work, we plan to analyze these results to determine whether agglutinate glass composition is related to the grain size distribution of the soil. The overall similarity of glass composition to that of local soil and the fact that agglutinate glass proportions are typically <50% are significant for space weathering and remote sensing of the lunar surface.

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