NEW TECHNOLOGY/OLD TECHNOLOGY: COMPARING LUNAR GRAIN SIZE DISTRIBUTION DATA AND METHODS.
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Introduction: Beginning with the Apollo program, our group has published close to 75% of the lunar regolith grain size data (e.g., 233 out of 317 analyses reported in [1]). We now use new laser diffraction technology to generate a comprehensive and comparable suite of grain size distributions for lunar soils. However, most published data were generated by mechanical sieving methods [2-11], so it is important to establish how historical data compare with data generated by new technologies. Details of our own sieving technique and protocol are given in [5].

Old Technology: Mechanical sieving produces (1) particle *size* distributions based on *weight* percent; (2) a small number of size fractions (bins) encompassing wide size ranges, and (3) problematic data below about 20 µm due to the physical limitations of sieving very fine grain sizes. Consequently, the accuracy of sieve-generated size distributions is contingent on actual particle densities and shapes. Variations in particle size distributions *within* the broad size fractions will not be detected, and size distributions below 20 µm may not have been accurately characterized. Mechanical methods may artificially skew distributions by disaggregating fragile particles (e.g., soil breccias), or facilitating narrow, elongate particles' passage through smaller screen meshes.

New Technology: Technologies have been developed that were not available during the Apollo program [12]. The technology we now use takes advantage of laser light scattering combined with a proprietary modified Mie scattering algorithm to compensate for irregularly shaped, non-transparent particles. The instrument used in this study is the Microtrac™ Bluewave, which has demonstrated the ability to provide reproducible measurements on small aliquots (~10 mg for the <20 µm fraction), and can be used to analyze a large number of samples in a reasonably short time.

Comparative Study: The purpose of this study is to 1) see how the old and new technologies' data compare, 2) test the assumption of a normal distribution within sieved fractions, and (3) reveal any finer-scale structures based on the smaller bin sizes of the laser diffraction technology. We have analyzed both "whole" curatorial aliquots (< 2mm), and sieved size fractions. For several samples, there was sufficient material in the <20 µm fraction to perform duplicate analyses and observe any variability that might be introduced by working with small sample splits (not practical with old mechanical methods).

Sample Selection: The well-studied Apollo 11 sample 10084 provided a "whole" sample comparison between the old and new technologies. Samples 63501,34 and 70161,1 were selected for individual size fraction comparisons, because enough material was available in the <90 µm sieved fractions for laser diffraction analysis.

Method: Isopropyl alcohol (IPA) was added to the lunar sample in a small beaker, and the mixture pipetted into the circulating system of the laser diffraction instrument. The recirculating unit was flushed and cleaned between samples to prevent cross-contamination and ensure particle-free initial conditions for each sample analysis.

Results: Table 1 compares Apollo 11 sample 10084 across methods and investigators. Laser diffraction technology extends data to the finest sizes, which has been shown to be important in other areas of planetary research [13].

Table 1. Comparison of grain size statisitics for Apollo sample 10084.

Source	Median µm	Mean µm	< 10 µm	< 2 µm
[2]	61.64	85.38	6.4 %	n.d.
[3]	55.67	52.0	9.2%	n.d.
[10]	55.1	51	14.2%	n.d.
[14] #1 H_2O*	66.49	117.0	18.3%	2.08%
[14] #3 H_2O*	30.05	85.61	22.7%	1.86%
#4 IPA* (unpublished data)	35.23	63.38	19.89%	1.68%

***Microtrac-generated data.**

Whole sample results. The data generated by both methods, sieving and laser diffraction of Apollo 11 sample 10084, are overlayed in Figure 1. The laser diffraction histogram more closely approximates a smooth curve, because it has more bins and narrower bin sizes. The laser diffraction histogram also reveals finer structures than do the sieve data.

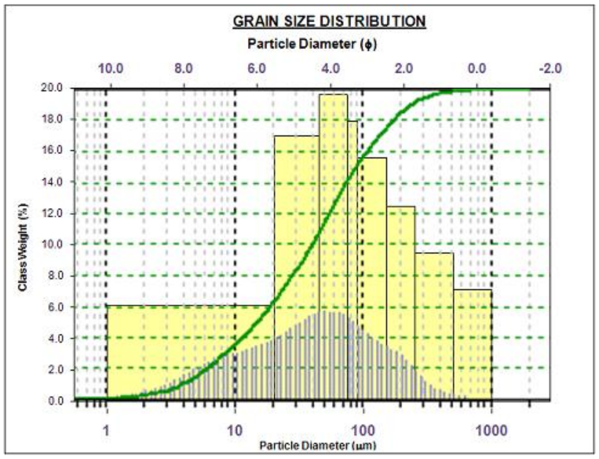

Figure 1. Comparison of particle size distribution data from the original sieving (yellow bars) of 10084 and new Microtrac™ analysis (purple).

*Size fraction results***.** Figure 2a-d shows the Microtrac™ results for four 64501,34 size fractions: 75-90 µm; 45-75 µm; 20-45 µm; and < 20 µm, respectively. The original size fractions appear to be well-sieved because smaller grain sizes are not significantly present in larger sieve fractions. The data suggests that normal distributions may be approached within the sieved fractions.

Conclusion: Laser diffraction technology generates reproducible grain size distributions and reveals new structures not apparent in old sieve data. The comparison of specific sieve fractions with the Microtrac distribution curve generated for those specific fractions shows a reasonable match for the mean of each fraction between the two techniques, giving us confidence that the large existing body of sieve data can be cross-correlated with new data based on laser diffraction. It is well-suited for lunar soils, which have as much as 25% of the material in the less than 20 µm fraction. The fines in this range are of particular interest because they may contain a record of important space weathering processes.

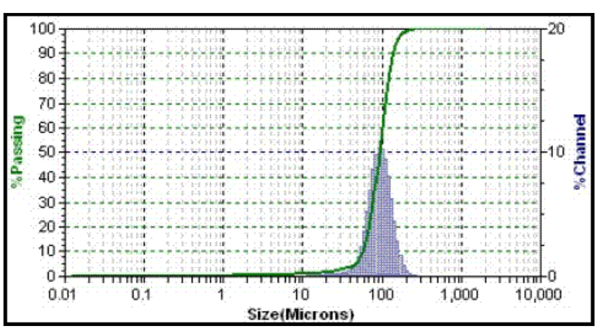

Figure 2a. Microtrac results for 75- 90 µm sieve fraction.

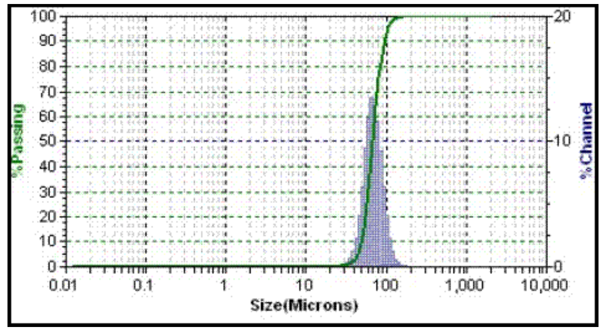

Figure 2b. Microtrac results for 45-75 µm sieve fraction.

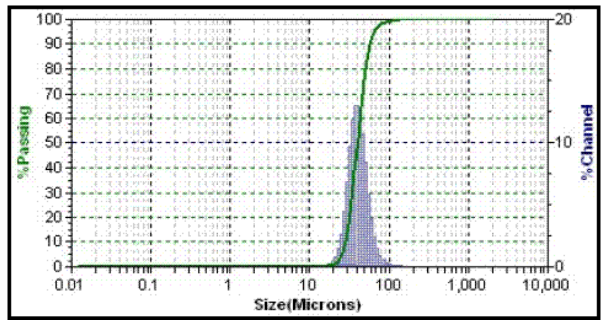

Figure 2c. Microtrac results for 20-45 µm sieve fraction.

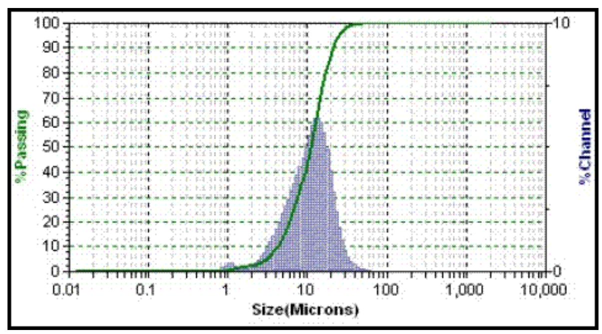

Figure 2d. Microtrac results for <20 µm sieve fraction.

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