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JSC-1: A NEW LUNAR REGOLITH SIMULANT

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"Simulants of lunar rocks and soils with appropriate properties, although difficult to produce in some cases, will be essential to meeting the system requirements for lunar exploration" (1). In order to address this need a new lunar regolith simulant, JSC-1, has been developed. JSC-1 is a glass-rich basaltic ash which approximates the bulk chemical composition and mineralogy of some lunar soils. It has been ground to produce a grain size distribution approximating that of lunar regolith samples. The simulant is available in large quantities (> 2000 lb; 907 kg). JSC-1 was produced specifically for large- and medium-scale engineering studies in support of future human activities on the Moon. Such studies include material handling, construction, excavation, and transportation. The simulant is also appropriate for research on dust control and spacesuit durability. JSC-1 can be used as a chemical or mineralogical analog to some lunar soils for resource studies such as oxygen or metal production, sintering, and radiation shielding.

Simulant Preparation. JSC-1 was produced from a basaltic pyroclastic sheet deposit located in the San Francisco volcanic field near Flagstaff, AZ. This pyroclastic deposit was erupted from vents related to Merriam Crater (35°20'N, 111°17' W). One basalt flow from a nearby vent has a K-Ar age of 0.15±0.03 million years. The pyroclastic sheet consists of "airfall ash and lapilli, usually black, locally red, as much as several meters thick . . . (which) forms broad, smooth-surfaced deposits over large areas"(2).

The ash was mined from a commercial cinder quarry near the south flank of Merriam Crater. Following coarse sieving the ash was comminuted in an impact mill. This method broke down the material by means of multiple impacts with other ash particles, resulting in minimal metal contamination. The ash from several grindings was allowed to air dry to an average water content of 2.7 wt% and was then mixed. Finally, it was loaded into plastic bags in 50 lb (22.7 kg) quantities and the bags were heat sealed.

Preliminary Simulant Characterization. The chemical composition of Merriam Crater ash is listed in Table 1. The composition of Apollo 14 soil sample 14163 is included for comparison (3). Normative minerals (CIPW) calculated from the Merrian ash composition include plagioclase, clinopyroxene, orthopyroxene, olivine, magnetite, ilmenite, and apatite (2). Efforts are underway to verify the chemical and mineralogical compositions of JSC-1.

The source quarry is located within an area mapped as "slightly porphyritic basalt" (2). This basalt is described as "containing less that 1 percent phenocrysts of olivine, clinopyroxene, and (or) plagioclase in an intersertal to intergranular groundmass of plagioclase, clinopyroxene, olivine, and opaque oxides, with or without glass." Scanning electron micrographs show broken glass and crystal fragments 300 um across and smaller (Figure 1). Glass particles invariably display broken vesicles with sharp edges. Crystal fragments are angular to sub-rounded, and many display the scars of impacts from the milling process.

The average grain size distribution of four splits of JSC-1 is shown in Figure 2. The upper and lower bounds of grain sizes from the Apollo soil samples are included for comparison (4). Table 2 compares the mean grain size of JSC-1 with median or mean size ranges from lunar soils. Tests to more precisely determine the grain size distribution of JSC-1 are in progress.

Availability. Approximately 30,000 lb (13,600 kg) of JSC-1 simulant is currently available for distribution to qualified investigators. The material is stored at the Texas A&M Lunar Soil Simulant Laboratory. Investigators desiring a portion of this material should address their requests to Dr. Walter Boles, Department of Civil Engineering, Texas A&M University, College Station, TX 77843 (Telephone 409-845-2493, fax 409-862-2800).

References. 1. McKay, D.S. and J.D. Blacic, 1991, Workshop on Production and Uses of Simulated Lunar Materials, *LPI Tech. Rpt. 91-01*, Lunar and Planetary Institute, Houston, TX, 83 pp. 2. Moore, R.B. and E.W. Wolfe, 1987, Geologic Map of the East Part of the San Francisco Volcanic Field, North-Central Arizona, *Map MF-1960*, U.S. Geological Survey, Washington, D.C. 3. Papike, J.J., S.B. Simon, and J.C. Laul (1982) *Rev. Geophys. Space Phys., 20*, pp. 761-826. 4. Carrier, W.D. III, J.K. Mitchell, and A. Mahmood, 1973, *J. Soil Mech. Found. Div.*, Am. Soc. Civil Eng., pp. 813-832. 5. Heiken, G.H., D.T. Vaniman, and B.M. French, 1991, *Lunar Sourcebook*, Cambridge University Press, Cambridge, 736 pp.

Table 1. Chemical Composition

Oxide	Merriam Crater Ash* Wt.%	Lunar Soil 14163** Wt.%
SiO_2	48.77	47.3
TiO_2	1.49	1.6
Al_2O_3	15.65	17.8
Fe_2O_3	1.71	0.0
FeO	8.88	10.5
MgO	8.48	9.6
CaO	10.44	11.4
Na_2O	2.93	0.7
K_2O	0.81	0.6
MnO	0.19	0.1
Cr_2O_3	---	0.2
P_2O_5	0.66	- - -
Total	100.01	99.8

* Sample 2001 of Ref. 2
** Ref. 3

Figure 1. Glass and mineral fragments from JSC-1. SEM image, frame width = 900 um

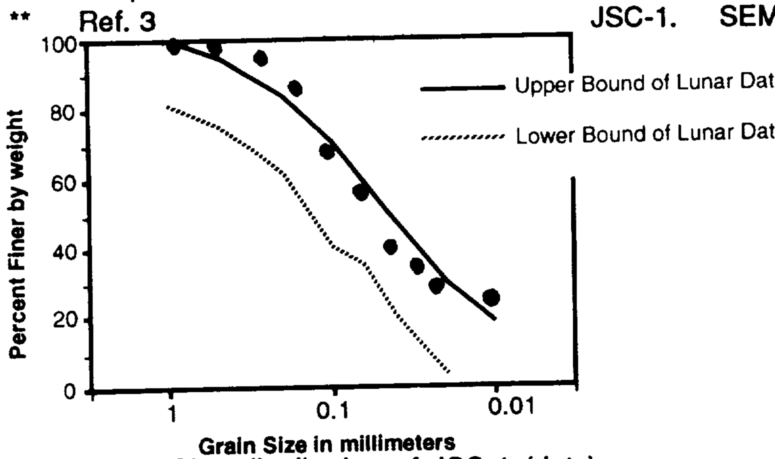

Figure 2. Size distribution of JSC-1 (dots) compared to lunar soil (Ref. 4).

Table 2. Grain Sizes

Sample	Size Range(um)*
JSC-1 (median)	70
Apollo 11 (median)	48 - 105
Apollo 12 (median)	42 - 94
Apollo 14 (median)	75 - 802
Apollo 15 (median)	51 - 108
Apollo 16 (mean)	101 - 268
Apollo 17 (mean)	42 - 166

* Ref. 5, Table 7.8