JSC MARS-1: MARTIAN REGOLITH SIMULANT

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We have developed a simulant to the regolith of Mars for support of scientific research, engineering studies, and education. JSC Mars-1 is the <1 mm size fraction of a palagonitic tephra (glassy volcanic ash altered at low temperatures). The material was collected from the Pu'u Nene cinder cone, located in the saddle between Mauna Loa and Mauna Kea volcanoes on the Island of Hawaii. Palagonitic tephra from this cone has been repeatedly cited as a close spectral analog to the bright regions of Mars [1,2,3].

Simulant Preparation and Analysis. The tephra was mined from a cinder quarry on the slope of Pu'u Nene cone. Soil overburden was removed and tephra was collected from a palagonitized zone 40-60 cm thick. The tephra was dried and sieved to separate the <1 mm size fraction. This material was packaged in moisture-proof containers for shipping and storage.

Preliminary Simulant Characterization. We analyzed a single sample from the area chosen for large scale simulant preparation. Splits were characterized by visible and near-IR (VIS/NIR) reflectance spectroscopy at the Johnson Space Center. X ray fluorescence (XRF) and loss on ignition (LOI) analyses were performed at Washington State University. We intend to publish detailed data from representative samples of JSC Mars-1 in the near future.

Spectra. JSC Mars-1 is yellow-brown in color. Figure 1 compares the VIS/NIR spectrum of the simulant to a composite martian bright region spectrum (atmospheric contributions removed) [4]. Both spectra contain a relatively featureless ferric absorption edge through the visible, an indication of a ferric absorption band in the 800-900 region, and relatively flat absorption in the near-IR. Bands at 1400 and 1900 nm in the simulant spectrum result from higher levels of H_2O and OH in the simulant than on Mars. The presence of the ferric features near 600, 750 and 860 nm in the martian spectrum imply higher levels of red (well-crystalline and pigmentary) hematite on Mars than in the simulant [5,6].

Chemical Composition. Table 1 lists the major and minor oxide composition of JSC Mars-1, as measured by XRF. This composition is compared to that of a typical Mars surface sample analyzed at the Viking lander 1 (VL-1) site [7].

Mineralogy. Morris et al. [3] published extensive analyses of a <1 mm tephra sample collected from Pu'u Nene. The sample is dominated by amorphous palagonite. The only phases detected by X ray diffraction are plagioclase feldspar and minor magnetite. These analyses constrained the abundance of phyllosilicates to <1 wt.%. Iron Mossbauer spectroscopy detected magnetite as well as traces of hematite, olivine, pyroxene and/or glass. The majority of iron was present as nano-phase ferric oxide (64%). These data yield a Fe^{2+}/Fe^{3+} ratio of 1/3.

Grain Size. Table 2 lists the published grain size distribution of Pu'u Nene tephra [3]. For comparison, the blocky material which covers 78% of the area near VL-1 on Mars ranges in size from 0.1-1500 µm [8].

Specific Gravity. The bulk specific gravity of JSC Mars-1 is 0.8 g/cm^3. This value can be increased to 0.9 g/cm^3 by vibrating the sample. The drift material near VL-1 has a specific gravity of 1.2 +/- 0.2 g/cm^3 and the blocky material has a value of 1.6 +/- 0.4 g/cm^3 [8].

Magnetic Properties. JSC Mars-1 contains a highly magnetic component. Approximately 25 wt.% of the sample can be lifted with a strong magnet. By comparison, observations of the Viking sample arm magnets indicate that the martian soil contains between 1-7% magnetic material [9].

Availability. We anticipate that approximately 9,100 kg (20,000 lb) of JSC Mars-1 will be available in 1997 for distribution to qualified investigators and teachers. The simulant will be stored at the Johnson Space Center. Anyone desiring a portion of this material should address their request to Dr. Carlton Allen (address above; telephone 281-483-2630, fax 281-483-5347).

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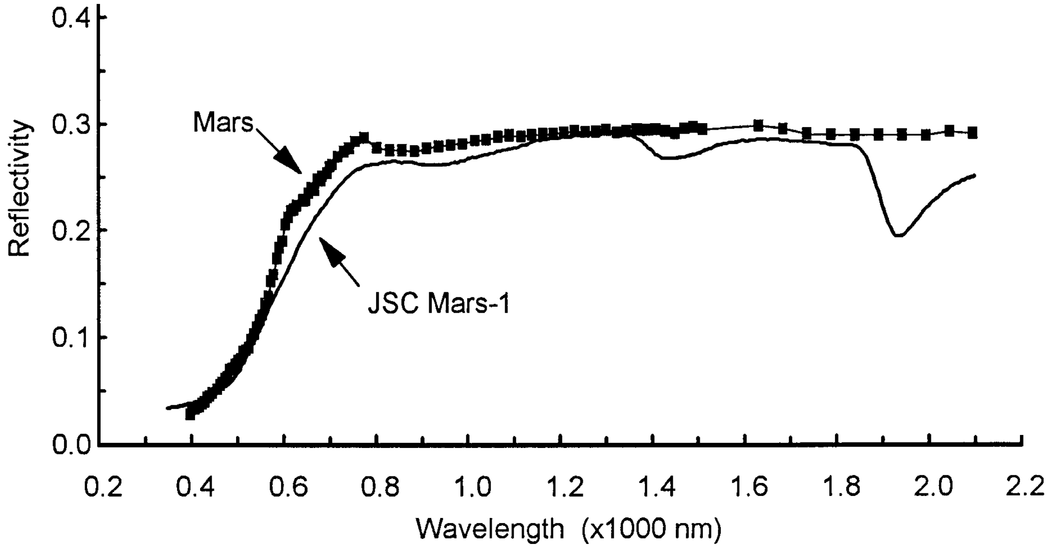

Figure 1. VIS/NIR reflectivity spectra of Mars Composite Bright Region [4] and JSC Mars-1

Table 1. Chemical Composition

	JSC Mars-1		Martian Surface Fines C-1
Oxide	Wt.%*	Wt.%**	Wt.%***
SiO_2	34.5	43.7	43
Al_2O_3	18.5	23.4	7.5
TiO_2	3.0	3.8	0.65
FeO	2.8	3.5	n.d.
Fe_2O_3	9.3	11.8	17.6
MnO	0.2	0.3	n.a.
CaO	4.9	6.2	6
MgO	2.7	3.4	6
K_2O	0.5	0.6	0
Na_2O	1.9	2.4	n.a.
P_2O_5	0.7	0.9	n.a.
SO_3	n.a.	n.a.	7
Cl	n.a.	n.a.	0.7
LOI****	21.8		

Table 1. (continued)

n.d. not detected n.a. not analyzed Fe^{2+}/Fe^{3+} = 1/3 * XRF ** XRF normalized without LOI *** Ref [7] **** Weight loss after heating for 2 hrs in air at 900°C (includes H_2O, SO_3, Cl)

Table 2. Pu'u Nene Tephra Grain Size*

Size (µm)	Wt.%
500-1000	21.4
250-500	29.5
150-250	20.8
90-150	12.9
45-90	9.2
20-45	5.4
<20	1.3

* Ref [3]