Influence of moisture content on albedo changes of JSC Mars-1 Martian simulant: a lesson for HiRISE? A. Maturilli[1], J. Helbert[1], T. L. Roush[2], M. D'Amore[1] [1]Institute for Planetary Research, German Aerospace Center DLR, Rutherfordstr. 2, Berlin-Adlershof, Germany, alessandro.maturilli@dlr.de), [2]NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035-1000, USA.

Introduction: It has been known for decades that bright and dark regions on the surface of Mars are exposed to the interaction of wind with the surface dust and are subject to profound changes on annual or decadal time scale, that have a strong impact on the global climate of Mars. Almost half of Mars' surface experienced such changes since the beginning of spacecraft observations [1].

Bare soil albedo, defined as the ratio of reflected to incoming solar radiation, is dependent upon the moisture level of the soil surface, as demonstrated nearly a century ago [2]. The change in albedo is due to water replacing air in the pores, that increases the likelihood of light absorption by the surface [3], but the nature of this dependence needs to be fully understood.

Idso et al. [4] concluded that albedo, when normalized to remove solar zenith angle effects, is linearly correlated with the water content of the uppermost layer of the soil.

A recent paper refutes this hypothesis, suggesting an exponential law better reproduces the albedo-moisture dependence [5], while Liu et al. [6] show that soil reflectance decreases with increasing soil moisture content until a critical point and then increases close to the mixture saturation level [6] .

In the Planetary Emissivity Laboratory (PEL) at German Aerospace Center (DLR) we measured the visible reflectance spectra of a JSC Mars-1 Martian soil simulator sample under several different moisture contents.

JSC Mars-1: The JSC Mars-1 was collected by the Johnson Space Center and is commonly used as the standard Martian soil simulant. It consists of the <1 mm size fraction of a palagonitic tephra (a glassy volcanic ash weathered at low temperature) collected in a region between the Mauna Loa and Mauna Kea volcanoes in Hawaii [7]. In the VIS and NIR spectral region, of JSC-1 is very close to the one of the Martian bright regions. Its chemical composition is close to data measured in situ by Viking Lander 1. The sample mineralogy is dominated by amorphous phases, with plagioclase feldspars and magnetite. Traces of hematite, olivine, pyroxene and glass are found. The comparison of those analysis with the recent discoveries of mineral phases on Mars confirm the relevance of JSC Mars-1 as Martian soil regolith simulator.

Reflectance measurements and albedo determination: The experimental facilities used in this work consist of the main PEL instrumentation to measure the emissivity of materials from 1 to 100 µm from low to very high (700K) sample temperatures, the supporting spectrometer laboratory for reflectance, transmittance and low/moderate temperature emissivity measurements [8,9], sample preparation facilities, and a large collection of rocks and minerals.

The reflectance measurements are carried out with a Fourier Transform Infrared Spectrometer (FTIR/FTNIR) Bruker IFS 88, purged with dry air to remove particulates, water vapor and CO_2. A Harrick Seagull^{TM} variable angle reflection accessory mounted in the spectrometer sample compartment allows measurement of the biconical reflectance of minerals at room temperature, under purging conditions. The visible spectral range from 0.4 to 1.1 µm under examination in this study has been covered using a Si-diode detector coupled with a quartz beamsplitter. For all the measurements in this experiment the incidence and emission angles has been se to be i=e=13°.

Sample preparation and measurements: Since this experiment was only a case study whose results will help to prepare a larger and more detailed set of measurements, we focused on the single 25-63 µm grain size fraction of sample, as a compromise between finer and larger fractions. A preliminary experiment using the exact same set-up indicated that for a few % of moisture no change in measured reflectance was observed, but for 50% moisture a major change in reflectance was observed and for 100% moisture the mixture saturation was longer reached.

An aluminum cup was filled with the JSC Mars-1 25-63 µm powder and put in an oven at 50° C for several hours to remove adsorbed water. For all the other cups, JSC Mars-1 25-63 µm particles were mixed with double-distilled water on a weight percent basis, as shown in Table 1.

Each sample in Table 1 has been immediately measured after its preparation in a dark plastic cup(except for "dry", where an aluminum cup was used) , to avoid changing the percentage of moisture added to the Martian simulant soil. To prevent dessiccation of the samples during the spectral measurement, a very low number of scans was chosen to record the measured interferogram. As a result, the data has been acquired almost instantaneously. Absolute reflectance measurements in the visible spectral range are obtained using halon as a calibration standard. After the end of all the measurements, the cups were collected together and photographed (Figure 1). The color changes for the different moisture content are already evident from this picture.

Sample	% Moisture
Dry	0
Wet1	5
Wet2	10
Wet3	20
Wet4	40
Wet5	30

Table 1: The moisture content for the cups used in this experiment.

Figure 1: The cups containing JSC Mars-1 sample 25-63 μm grain size fraction at different level of moisturization.

Results: Figure 2 shows the reflectance spectra (from 0.45 to 1.1 μm) of the six samples. The "dry" cup does not differ from the wet1 and wet2, suggesting that albedo is insensitive to small changes in the amount of moisture in the soil, In fact, a limited amount of water in the soil seems to increase, a little bit, the reflectance of the soil. Only at wet3 (20% moisture) and wet5 (30% moisture) does the reflectance of JSC Mars-1 begin to look darker with respect to dryer conditions. The "big step" in reflectance change happens at moisture values around 40% in weight.

For these measurements, we defined the "visual albedo" as the integral of the measured reflectance in the visible spectral range (0.45-0.76 μm). Figure 3 shows the visual albedo of the six samples as a function of water content. Like the reflectance, the "dry" cup does not differ from the wet1 and wet2, i.e. small amount of moisture in the soil. However, at wet3 and wet5 the Martian simulant albedo values decrease with respect to dryer conditions. Similar to reflectance, the "big step" in albedo change happens at moisture values around 40% in weight.

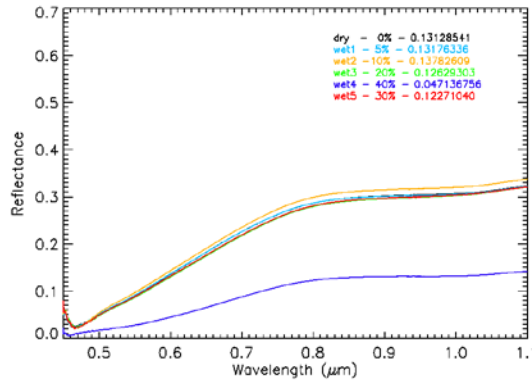

Figure 2: The visible biconical reflectance spectra of JSC Mars-1 25-63 μm at different moisturization levels and the calculated "visual albedo".

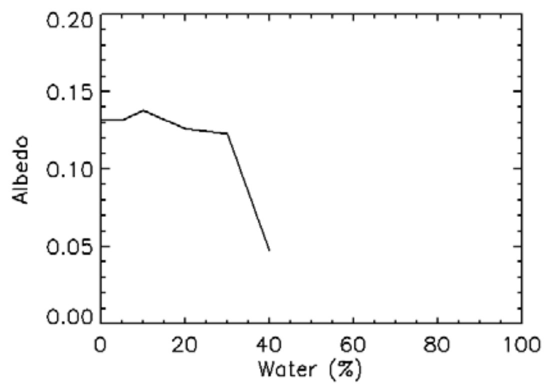

Figure 3: Albedo vs. water content (in weight %) as result of our experiment.

Conclusions and outlook: To investigate the relation between albedo (calculated from absolute reflectance measurements in the visible spectral range) and moisture content, a typical Martian soil simulant was mixed with double-distilled water in various weight percents from 0 to 40. The albedo remained almost constant up to 30% of moisture, then dramatically decreased between 30% and 40%. These initial results require verification with other grain size ranges and Martian simulant soils on with extended range of moisture contents.

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