EFFECTS OF MARS ANALOGUE DUST DEPOSITION ON DUV RAMAN SPECTRA: IMPLICATIONS FOR THE MARS2020 PERSERVERANCE ROVER SHERLOC INSTRUMENT

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Introduction: The Scanning Habitable Environments with Raman & Luminescence for Organics & Chemicals (SHERLOC) instrument suite includes a deep ultraviolet (DUV) Raman and fluorescence instrument on the robotic arm of the Mars2020 (M2020) Perseverance rover [1]. When sufficiently thick dust coatings are present, substrate surfaces are not detected, and mineralogical information not obtained. For example, the effect of palagonitic dust coatings as a function of depth to various substrates on thermal emission, VNIR, and Mössbauer spectra are reported by [2, 3]. In this study, we use the same palagonitic dust to study the effect of dust coating thickness on DUV Raman spectra.

Materials and Methods: Rock and mineral substrates were slabs (~4 x 0.5 cm) of hand samples of olivine (Twin Sister Range, WA) and pyroxene (enstatite; Bamble, Norway). The palagonitic tephra used as the source for dust material is HWMK101 (<53µm) [4]. An air-fall method of depositing the palagonitic dust was developed previously to uniformly coat the rock and mineral substrates [5]. This method involves mechanically suspending material from a container of HWMK101 with a fan in a chamber opened to a larger enclosed chamber by a series of small holes (~1 mm). The dust then settled on the substrates. Dust thicknesses were measured by a vertically calibrated optical microscope using as focal points substrate and dust surfaces. Olivine and enstatite slabs were chosen as substrates because their DUV Raman spectra were characterized by well resolved peaks with negligible fluorescence.

Raman spectra were collected on the Analogue Complementary Raman for Operations oN Mars (ACRONM) DUV (248.6 nm) instrument at the NASA Johnson Space Center in the ARES Raman Laboratory. ACRONM is an analogue for the Mars2020 Perseverance rover SHERLOC Raman instrument. The incident laser beam on the target is donut in shape with a diameter of ~50 µm. Measurements were conducted in air at ~25°C under ambient pressure conditions and with approximately equivalent instrumental and focusing conditions, enabling comparison of peak amplitudes among samples after scaling to equivalent integration times.

Discussion: The amplitude substrate Raman peaks generally decreases with dust thickness over the substrate (Fig. 1, 2, and 3). The spectrum in each figure with no intensity at the substrate Raman peaks (i.e., at ~650 and ~1000 cm^{-1} and ~840 cm^{-1} for enstatite and olivine slabs, respectively) corresponds to that for an optically thick sample (~1-2 mm) of HWMK101 dust. ParticleScout software was used to analyze the surface area coverage and the largest particle size of the dust layer. The first dust deposition yielded a surface area coverage of 11.4% and largest particle size of 53 µm. The second dust deposition yielded a surface area coverage of 16.9% and 54 µm largest particle size. The third dust deposition yielded a surface area coverage of 24.5% and 63 µm largest particle size. Given the maximum particle size of 53 µm of the HWMK101, particle aggregation effects begin after the second dust deposition. Aggregation can be seen in the third images from the bottom in Fig. 1. The thickest coating for this experiment was ~100 µm.

Summary: DUV Raman spectra for dust air-fall deposited on olivine and enstatite substrates results in decreasing substrate signal with increasing dust coat thickness. The Raman peaks of underlying substrate can be detected through coatings at least ~100 µm thick. This study has implications for current and future observations made by SHERLOC on the M2020 Perseverance rover, with respect to measurements in the presence of surface dust.

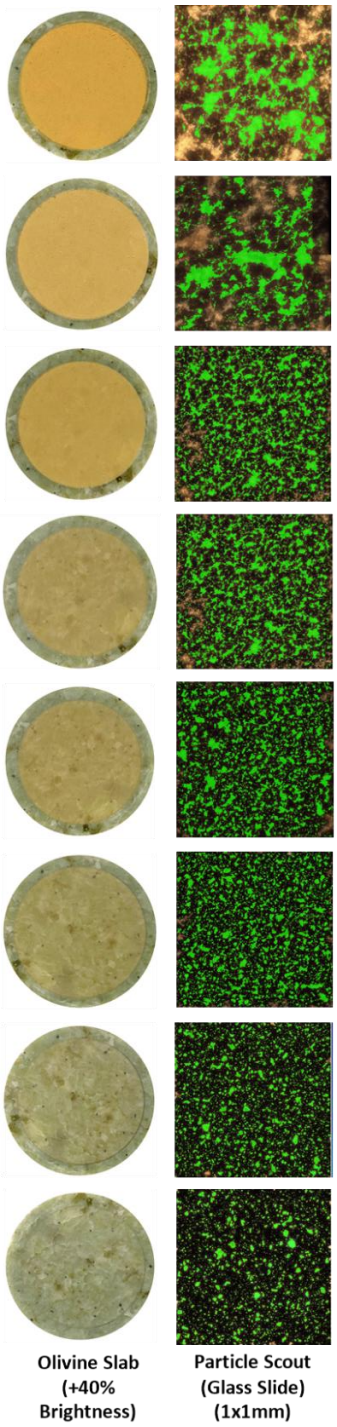

Figure 1. Olivine substrates with increasingly thick dust coatings from bottom to top (left). Particle Scout particle count images of dust on glass slide equivalent to horizontally located slab image (right).

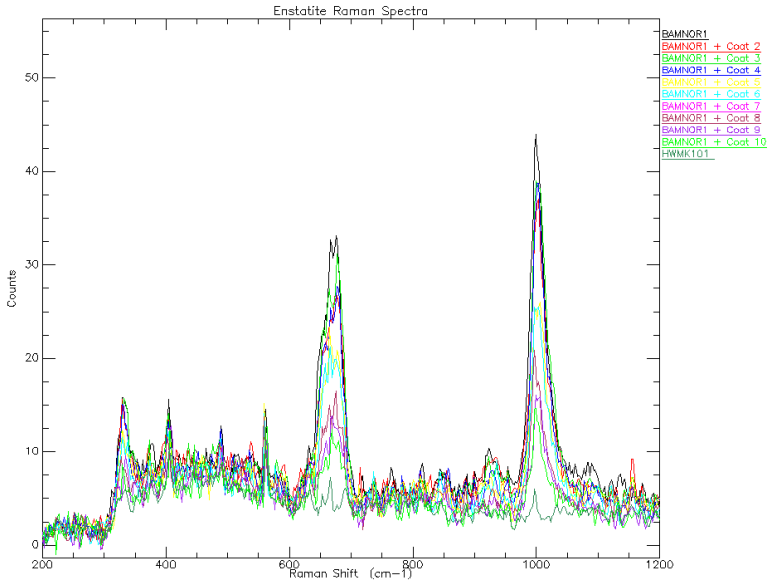

Figure 2. Plot of the Raman signal intensity of the enstatite substrate with subsequent dust coatings and palagonite HWMK101 dust spectra.

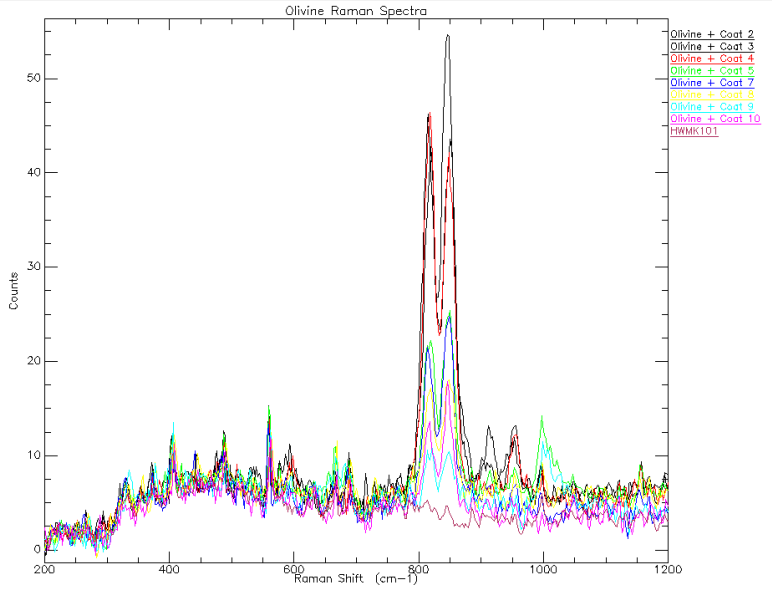

Figure 3. Plot of the Raman signal intensity of the olivine substrate with subsequent dust coatings and palagonite HWMK101 dust spectra.

References: [1] Bhartia *et al.*, 2021, *SSR*, 217, 1. [2] Crisp and Bartholomew, 1992, *JGR*, 97, 14, 691. [3] Johnson, 1999, 30th LPSC, Abstract #1214. [4] Hollis *et al.*, 2021, *Icarus*, 357, 114067. [5] Graff *et al.*, 2001, LPSC, Abstract #1899.