Introduction

- Thin mantles of dust are recognized as the cause of an unexpected spectral contribution in measurements of minerals and rocks taken by the Miniature Thermal Emission Spectrometer (Mini-TES) instruments on the Mars Exploration Rovers (MER; Spirit and Opportunity).
- If not corrected, spectral effects caused by thin mantles of dust can greatly hinder mineralogical interpretation of rock surfaces (Fig. 1).
- Here we present preliminary results of laboratory and modeling efforts to identify the effects of thin dust mantles on planetary surfaces to aid in the interpretation of spectroscopic data.

I. Background: Mini-TES data

- Thin dust coatings (<5 μm) have been considered negligible until recently in mid-infrared measurements (MIR, ~200 – 2000 cm⁻¹).
- Thin mantles of dust contribute spectral features to Mini-TES spectra that are similar to those caused by downwelling radiance from atmospheric dust and were initially attributed as such by [4].

- The radiative effects of atmospheric dust and cannot solely account for the magnitude of the spectral features.
- They also lack the radiative effects of atmospheric CO₂, which should also be present if atmospheric dust is responsible for the observed spectral features.
- To contribute spectral features to the measured spectra, the dust (temperature = T₂), must be thermally isolated from the substrate (temperature = T₁). Thin dust coatings (>5 μm) produce different spectral effects → result in a detection of spectral contrast.

II. Goals

- Our goal is to combine both laboratory measurements and modeling to better understand the behavior and underlying physics of how thin dust coatings can affect TIR spectral measurements. This information will aid in the interpretation of spectroscopic data.

III. Motivation

- The spectral effects of thin dust coatings present in Mini-TES data have yet to be observed in the laboratory.

Possible Reasons:

1. Previous investigations did not control for dust particle size such that large clumps (>5 μm in diameter) were deposited on surfaces (Fig. 2a) → linear mixing effects
2. The dust and substrate were not thermally isolated, so that the dust and the subtrate had the same temperature → no net effect on measured radiance

IV. Thermally Isolated Surfaces

- A similar spectral contribution is due to dust deposited on the periscope mirror through which Mini-TES makes all of its observations.

⇒ Because the dust and the rock are not in contact they can have two distinct temperatures.

- Laboratory measurements of dusty mirrors will allow us to understand some of the underlying physics of how thin dust coatings can affect spectral measurements (Fig. 4; Results in Box Vc).

V. Laboratory Measurements

- Updated the laboratory set-up of [2] to include a cover above the substrate. Set-up consists of a hand pump or compressed air and a plastic box (Fig. 4). The pump is used to disperse dust into the air within the box. A rock (or other) surface is then mantled by the dust that settles out.

⇒ From the settling velocities, times can then be calculated for which it is necessary to remove the cover to limit the deposition of particles of a given size.

- Substrates were deposited with increasing quantities of dust to see what effects particle size, thickness and surface coverage have in MIR spectra.

Vc. Preliminary Lab Results: Dust Coated Mirrors

⇒ The temperature contrast between the dust and the target mimics effects similar to those caused by thin mantles of dust in Mini-TES observations.

- Substrates:

⇒ Rocks of basaltic composition (Results in box Vb)
⇒ Parabolic Mirror (Results in box Vc)

- Dust: Na-Montmorillonite (phyllosilicate)

VI. Radiative Transfer Modeling

- We started by using a similar radiative transfer approach used to model atmospheric dust due to its similar spectral behavior.

⇒ The radiative transfer (RT) model accounts for radiance emitted by the substrate and dust, and radiation absorbed and scattered by the dust (Figure 7).

⇒ We model a thermally isolated mono-layer of spherical dust to see what effects particle size, thickness and surface coverage have in MIR spectra.

⇒ A two/four-stream approach as outlined by [8] is used to calculate the modeled radiances using scattering parameters calculated from Mie theory [7]. Apparent emissivities are then calculated from these values.

References