EXOMARS TRACE GAS ORBITER MATMOS INSTRUMENT: PRELIMINARY STRATEGY FOR DEVELOPMENT OF A DUST SPECTRAL LIBRARY. E.A. Cloutis[1], V.J. Hipkin[2], P.O. Wennberg[3], M.J. Wolff[4], J.M. Stromberg[1], G.M. Berard[1], P. Mann[1], and the MATMOS Team. [1]Department of Geography, University of Winnipeg, 515 Portage Avenue, Winnipeg, MB, Canada R3B 2E9; e.cloutis@uwinnipeg.ca, [2]Canadian Space Agency, 6767 route de l'Aeroport, St. Hubert, QC, Canada J3Y 8Y9, [3]Linde Center for Global Environmental Science, California Institute of Technology, Pasadena, CA, USA 91125, [4]Space Science Institute, 4750 Walnut St., #205, Boulder, CO, USA 80301-2532.

Introduction: The ExoMars Trace Gas Orbiter (EMTGO) mission is a joint ESA/NASA mission scheduled for launch in 2016. The four prioritized science goals include:

- Detect a broad suite of atmospheric trace gases and key isotopes
- Characterize the spatial and temporal variation of methane and other key species
- Localize the sources and derive the evolution of methane and other key species and their possible interactions, including interactions with atmospheric aerosols and how they are affected by the atmospheric state
- Image surface features possibly related to trace gas sources and sinks.

A total of five science instruments were selected for flight on EMTGO, including the Mars Atmospheric Trace Molecule Occultation Spectrometer (MATMOS).

Description of MATMOS: MATMOS is a high-resolution solar occultation Fourier transform infrared spectrometer. MATMOS will conduct solar occultation limb viewing, allowing it to probe different parts of the atmosphere with ~ 3 km vertical resolution (Figure 1). The instrument will acquire spectra from 850 to 4300 cm^{-1} with 0.02 cm^{-1} spectral resolution – a necessary condition for trace gas analysis. The operating parameters for MATMOS are optimized for atmospheric trace gas detection and characterization.

Dust Characterization: In addition to the primary role of MATMOS for trace gas analysis, it will also be used to characterize the composition of atmospheric mineral dust. IR analysis has long been recognized as an effective tool for Mars atmospheric dust characterization [1]. A number of important mineral species possess strong primary vibration bands in the wavelength region covered by MATMOS [e.g., 2].

Importance of Dust: IR analysis of atmospheric dust is important for a variety of reasons. These include:

- Its role as condensation nuclei for atmospheric volatiles
- As a probe of surface mineralogy [e.g., 1]
- As a tracer of atmospheric circulation
- To understand dust-atmosphere interactions
- For robust retrieval of atmospheric gas properties
- Its role in atmospheric and surface heating

Dust Spectral Measurements (1): To provide information useful to analysis of MATMOS data for both atmospheric gas retrieval and compositional studies of atmospheric dust, we are establishing a multi-year strategy and associated facility for development of a dust spectral library that will satisfy the primary science requirements.

Measurement Trade Space: One of the first requirements to be determined in our analysis is the importance of simulating Mars atmospheric conditions in the laboratory. As our primary goal is to provide reliable dust spectra for analysis of MATMOS data, it is crucial that we determine what characteristics of the Mars atmosphere (Table 1) should be reproduced in the laboratory when conducting dust spectral measurements (as described below), and the loss of information that may occur if some or all of these parameters are ignored or relaxed. A trade space analysis will be undertaken to determine the impact of ignoring or approximating any or all of the parameters listed in Table 1 in the course of laboratory dust spectral measurements.

Dust Characterization: In the course of our analysis, we will compile information on the full range of minerals known to exist on Mars. This information will be derived largely from reviews of analyses of Mars meteorites [e.g., 3] and remote sensing data [e.g., 4-6]. This information (which will be constantly updated) will inform the choice of minerals to be used for spectral measurements. Each mineral species included in this study will be characterized compositionally (e.g., XRF, microprobe, light element analyzer) and structurally (XRD). Powders produced for spectral measurements from these samples will also be characterized physically (SEM), as particle shape can affect scattering properties.

Dust Spectral Measurement (2): IR dust spectra are affected by factors such as shape and size (in addition to composition and structure). To provide robust data, we tentatively plan to conduct spectral measurements of our samples at the Planetary Spectrophotometer Facility at the University of Winnipeg in three ways:

Long-path dust transmission spectra: Our planned primary measurement strategy for acquiring dust spectra will involve the use of a long path (>10 m) White cell that will be interfaced to our Bruker Vertex 70 spectrometer (which can cover the full MATMOS spectral range as well as the visible wavelength region bands of the solar imager, and has a spectral resolution of 0.2 cm^{-1}). Unsorted dust of a single mineral species will be introduced into the cell. Spectra will be acquired periodically over several days. Stokes settling allows us to acquire spectra of progressively finer fractions. Stokes settling in the chamber also effectively mimics how dust settles out of the Martian atmosphere after a dust storm. It also avoids some of the shortcomings and limitations inherent in physical/mechanical/chemical production of sorted fine-grained dust fractions [7-9].

Dust-covered transparent disk spectra: For more controlled measurements, we will introduce mineral dust into an enclosed chamber containing a series of visible-IR transparent disks (e.g., CaF_2) and allow the dust to settle via Stokes settling. By exposing and covering the disks at predetermined time, we will be able to produce dust-covered disks with restricted dust size ranges. These disks will be measured via transmission spectroscopy and will be available for subsequent particle shape characterization by SEM. Such measurements will serve as a useful check on the White cell measurements.

Reflectance spectra: A third methodology will involve preparing pressed disks of mineral samples with mirror finishes. Specular measurements will be made of the disks. From these measurements, we will be able to derive optical constants. These parameters will be useful adjuncts to the transmission spectral measurements, and enable optical modeling of dust spectra to be undertaken [10-13].

Summary: EMTGO and MATMOS have the potential to revolutionize our understanding of the composition and evolution of the Mars atmosphere. High-quality laboratory dust spectra will allow us to better determine the composition and physical characteristics of airborne Martian dust: retrieval of MATMOS aerosol properties will be more robust. MATMOS rich data sets of co-located gas and aerosol profiles will enable new investigations, such as an investigation into heterogeneous chemistry.

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Acknowledgements: This study is supported by the Canadian Space Agency, NSERC, and the University of Winnipeg. The University of Winnipeg's Planetary Spectrophotometer Facility was established with support from the Canada Foundation for Innovation, the Manitoba Research Innovations Fund, and the Canadian Space Agency.

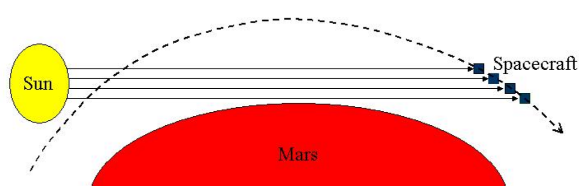

Figure 1. Operating principle of the MATMOS spectrometer based on solar occultations.

Table 1. Potentially important Mars atmospheric characteristics that may impact infrared transmission spectra of mineral dust (besides dust composition).

Atmospheric composition
Temperature
Pressure
Temperature vs pressure
Relative humidity
Dust loadings
Dust grain size
Dust shape
Volatile condensation