

REFLECTANCE SPECTRA AND OPTICAL CONSTANTS OF MARS ALTERATION PRODUCTS: HYDRATED MAGNESIUM SULFATES. K. M. Pitman¹, E. Z. Noe Dobrea¹, J. B. Dalton III², C. S. Jamieson², and W. J. Abbey². ¹Planetary Science Institute, 1700 E. Fort Lowell Road, Suite 106, Tucson, AZ 85719 USA <pitman@psi.edu>, ²Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109 USA.

Introduction: Diffuse reflectance spectra and optical functions, or "constants," quantify the refractive and absorptive properties of minerals and are used to generate synthetic spectra of linearly or intimately mixed minerals to compare to spacecraft data. To maximize the scientific return from visible and near-infrared (VNIR, $\lambda=0.35\text{-}5\ \mu\text{m}$) mapping spectrometers aboard Mars orbiters, we will provide the data needed to constrain the abundance of candidate hydrated Mg-sulfates, as well as their distributions on the martian surface. Specifically, we will derive optical constants from laboratory VNIR reflectance spectra obtained at 200 and 300 K for hydrated Mg-sulfates, which are aqueous alteration products observed on Mars.

Hydrated Mg-Sulfates on Mars: Sulfates have been inferred for Mars since the Viking and Pathfinder spacecraft missions [1,2], observed on Mars with NASA IRTF, Phobos 2 ISM, MGS TES, MER Spirit and Opportunity, OMEGA, and CRISM [3-11], and found in the Mars-derived SNC meteorite class [12-16]. Several Mg-bearing mono- and polyhydrated sulfates in particular are of interest. Epsomite and hexahydrate salts are expected to form on Mars when $\text{MgSO}_4/(\text{SO}_4+\text{Cl})$ -rich solutions are concentrated [17]. Although epsomite and hexahydrate may not be stable on the martian surface [18-19], amorphous derivatives of epsomite and hexahydrate or lower order Mg-sulfate hydrates such as kieserite might be [20-22]. These predictions have been corroborated by positive identifications of Mars, e.g., kieserite and polyhydrated sulfates [23-27], notably in Terra Meridiani [28] and Meridiani Planum [29]. Determining the exact type of Mars sulfates (Mg- versus Fe-rich) may lead to more information on the epoch of formation or humidity conditions on Mars during their formation [30-33].

Methodology: We will synthesize Mars-relevant hydrated Mg-sulfate samples from reagent-grade epsomite via dehydration or dissolution/precipitation at controlled temperature and humidity, prepare the samples in different size fractions in a glove box under controlled T, P and test them for purity via XRD analysis immediately afterwards, acquire laboratory VNIR reflectance spectra multiple times (i.e., immediately after synthesis, after preparation, and after XRD analysis) to characterize absorptive properties of each material (Fig. 1), and derive optical constants n and k from reflectance peak parameters via scattering theory

+ subtractive Kramers-Kronig analyses to quantify the intrinsic light scattering properties of the samples (Fig. 2). We will focus on two main variables:

Temperature: There is a need for both optical constants and reflectance spectra that represent the extremes of Mars surface temperatures ($T \sim 280\text{-}300\ \text{K}$ in equatorial regions to down to $150\text{-}200\ \text{K}$ in polar winter). Distinguishing between chemical subtypes of sulfates in Mars soil analogs spectrally becomes increasingly more possible as surface temperatures go below $260\ \text{K}$ [34]. We will target $T=300\text{K}$ and 200K .

Grain size: A few recent studies [e.g., 35] have varied pressure-temperature or dehydration conditions to resemble Mars, but at the expense of measuring multiple particle sizes. The particle sizes in past studies [e.g., 36-40] fall into two categories, motivated by IRTM/TES and MER results: atmospheric dust/silt-sized (e.g., $< 45\ \mu\text{m}$ size fraction) or sand-sized ($\sim 200\ \mu\text{m}$). We will focus on different particles sizes that have not been measured before ($53\text{-}75\ \mu\text{m}$, $125\text{-}150\ \mu\text{m}$, and $225\text{-}250\ \mu\text{m}$), to better represent aqueous terrains such as fluvial and lacustrine deposits and allow us to converge on the best set of optical constants (which should be independent of particle size).

Significance: Our spectral data and optical constants will provide the means to distinguish between polyhydrated sulfates and identify Mg-sulfates of different hydration states on Mars, from which Mars researchers may further infer how active groundwater, frost, and atmospheric processes once were. Transport and alteration mechanisms of Mars sulfates can also be inferred based on present distributions and abundances of hydrated sulfates. While modeling the latter is possible for Ca-sulfates, similar modeling for hydrated Mg-sulfates cannot be performed without the optical constants that we will provide. Because the hydration state of Mg-sulfates implies particular pressure, temperature, and humidity conditions and the time duration of those conditions, Mars abundances modeled using our data could be correlated to such conditions at different Mars epochs. Our deliverables will also be essential to future studies of proposed landing sites for the Mars Science Laboratory.

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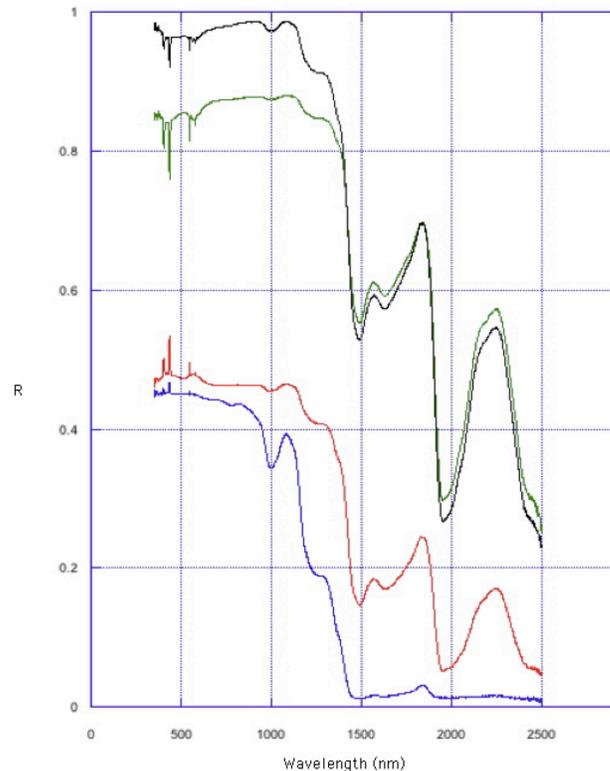


Fig 1: Raw diffuse reflectance spectra + offset in vertical axis for synthesized epsomite (red, green lines = $d < 125 \mu\text{m}$; blue, black lines = coarse particles).

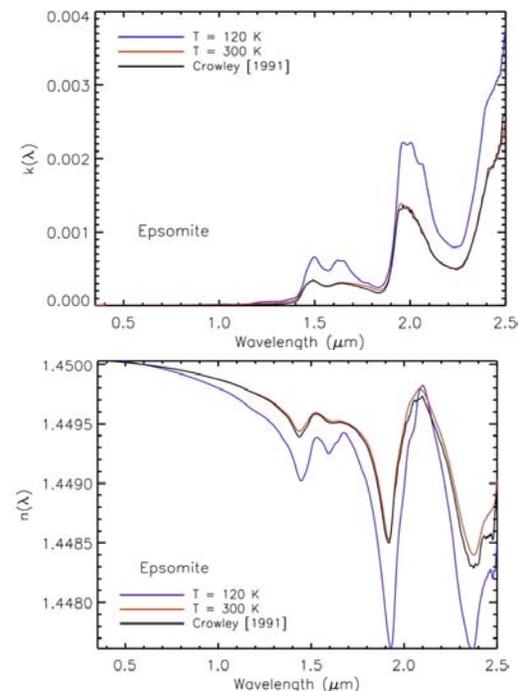


Fig 2: Optical functions k and n for epsomite for low (blue) and room temperature (red, black lines) [41]; reflectance data acquired in this study will be combined with these data to optimize results.