

THERMAL EMISSION SPECTROSCOPY OF SULFATES: POSSIBLE HYDROUS IRON-SULFATE IN THE SOIL AT THE MER-A GUSEV CRATER LANDING SITE. Melissa D. Lane¹, ¹Planetary Science Institute, 1700 E. Fort Lowell Road, Suite 106, Tucson, AZ 85719 (lane@psi.edu).

Introduction: Sulfates are likely to be present on Mars as indicated by the sulfur abundances measured at the Viking and Pathfinder landing sites (~5-10% by weight SO₃) [1-3] and because of Mars' strongly oxidizing environment. Telescopic observations of Mars tentatively identified weak sulfate bands in near infrared [4] and thermal infrared [5] data. The currently orbiting midinfrared instruments (TES, THEMIS) and the Mini-TES on the Mars Exploration Rover landers may enable a positive identification [6] and determination of the chemistry of the sulfates. Critically important to the identification of these minerals is the presence of their spectra in a spectral library.

There exist approximately 370 sulfate-mineral species [7]. Sulfate minerals occur in volcanic, hydrothermal, evaporitic, and chemical-weathering environments.

Objective: The objective of this study is the presentation of midinfrared emissivity spectra (2000 to 200 cm⁻¹; 5 to 50 μm) of a variety of sulfate minerals that will be well characterized for inclusion in the online spectral library hosted by Arizona State University.

Sample Descriptions and Results: To date, 54 sulfate-bearing mineral samples were collected worldwide and analyzed in thermal emission using ASU's Planetary Exploration Laboratory. Each generated spectrum (2000 to 200 cm⁻¹) was acquired over either 160 or 270 scans at 2 cm⁻¹ sampling. Additional details of the data calibration are presented in [8-10]. Sulfates and sulfate-bearing minerals exhibit unique thermal emission (midinfrared) spectra (Figure 1). Each chemical composition produces a distinct spectrum as a result of the fundamental vibrational modes of the crystal structure and their associated overtones. Cation complexation

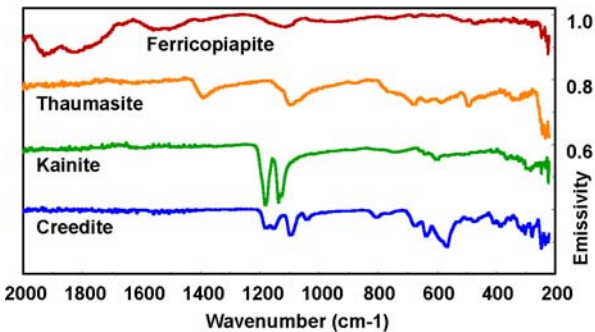
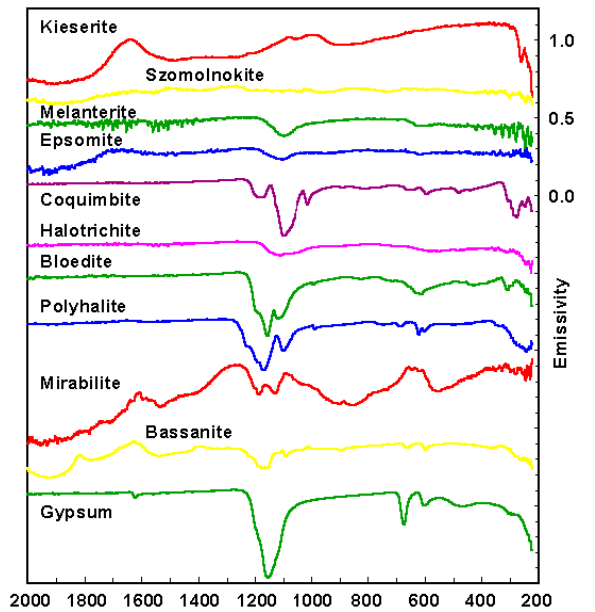
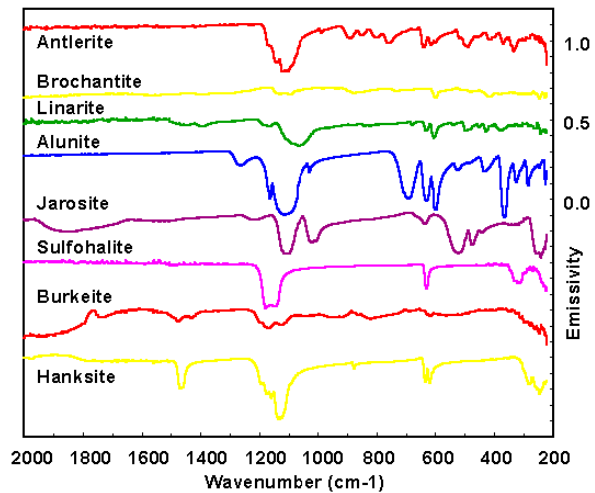
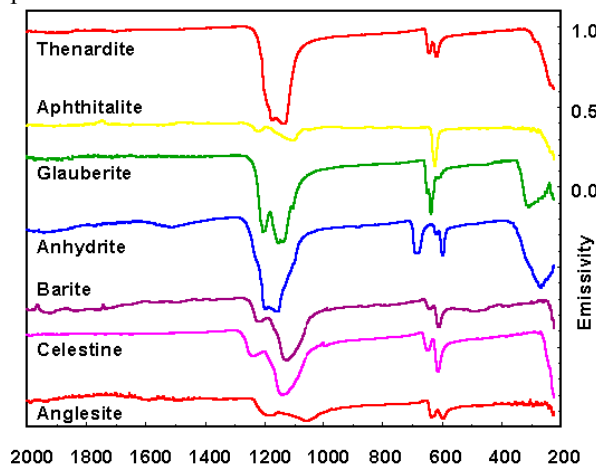


Figure 1a-d: Emissivity spectra of various sulfates, ordered according to Strunz classification (anhydrous sulfates; anhydrous sulfates w/ add'l anions; hydrous sulfates; hydrous sulfates w/ add'l anions).

of SO_4^{2-} controls the vibrational spectral features. In a solid-state sulfate, features appear at $\sim 1000\text{-}1250$ (ν_3), $\sim 500\text{-}700$ (ν_4), and $\sim <300$ (ν_2 , formerly forbidden) cm^{-1} [11,12].

Hydrous Iron-Sulfate at the MER-A Gusev Crater Landing Site: At the time of this writing the MER-A *Spirit* rover still is sitting on the lander. With the preliminary mini-TES data, P. Christensen has said in a press release (1/9/04) that the soil surrounding the landing site is composed of a silicate matrix with additional constituents of “an unidentified mineral that contains bound water” and a “carbonate”. The “carbonate” was inferred from the presence of two emissivity minima at approximately 1600 and 1400 cm^{-1} . The “bound water” mineralogy was inferred from the emissivity maximum at approximately 1650 cm^{-1} . These interpretations were based upon a similar spectrum presented by [13].

Comparison of the mini-TES soil spectrum to the suite of sulfates from this study shows that a hydrous iron-sulfate mineral (HIS), like ferricopiapite, rozenite, or szomolnokite, may be in the soil on Mars (in addition to a silicate) and account for the above-mentioned “carbonate” and “bound water” features (Figure 2).

These HIS features satisfy the spectral character of the mini-TES data in the 1800 to 1100 cm^{-1} range. X-ray diffraction analysis has verified the ferricopiapite sample composition. Although XRD analyses of the szomolnokite and rozenite samples remain to be done, their spectral similarity suggests that they are hydrous iron-sulfates. This compositional prediction of HIS simplifies the composition of the Martian soil because two separate minerals---a “carbonate” and “a mineral with bound water”--- in addition to the silicate matrix are not required to satisfy the spectral features.

The Gamma Ray Spectrometer (GRS) team [14,15] identified hydrogen in the near surface of Mars to be an indicator of water. Many sulfates contain OH or H_2O and water-bearing sulfates could certainly be wide-spread and abundant on Mars. Hydrous iron-sulfate minerals could account for the low-latitude hydrogen signature measured by the GRS.

Future Work: Mixtures will be made and emissivity spectra acquired a fine-grained silicate (Hawaiian palagonite) and the ferricopiapite, rozenite, and szomolnokite samples in order to observe the spectral character surrounding the silicate band in the 1200 to 700 cm^{-1} region and at other wavelengths to determine if hydrous iron-sulfate remains a viable soil component for the soil at the MER-A landing site. Additionally, data to be returned shortly from the Mössbauer spectrometer and the APXS on *Spirit* should be able to support or refute the presence of hydrous iron-sulfate in the Martian soil.

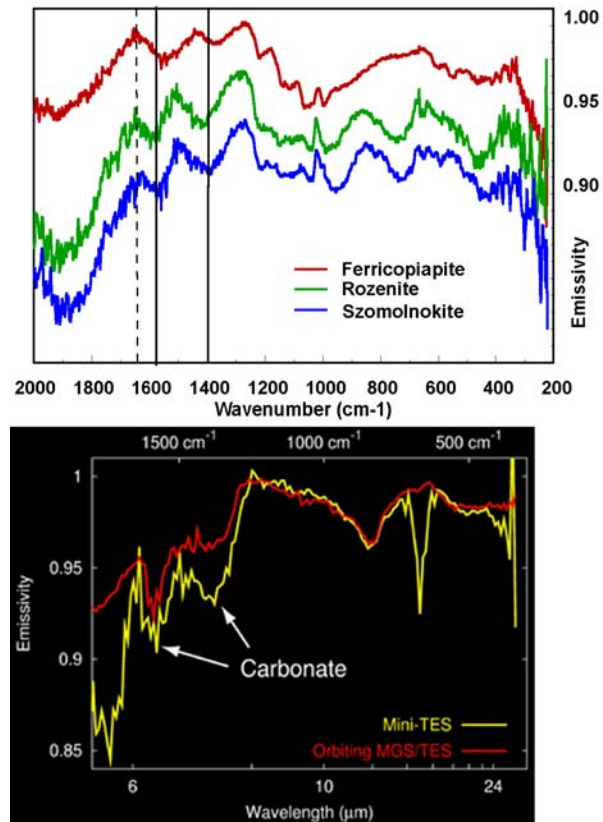


Figure 2: Emissivity spectra of hydrous iron-sulfate (HIS) minerals compared to the spectra of the Martian surface as presented by P. Christensen during the 1/9/04 Mars Exploration Rover press conference. The similarities in spectral shape indicates that hydrous iron sulfates could account for the “carbonate” and “bound water” features inferred from the mini-TES data.

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