

WHAT LURKS IN THE MARTIAN ROCKS AND SOIL? INVESTIGATIONS OF SULFATES, PHOSPHATES, AND PERCHLORATES

## Mid-infrared emission spectroscopy and visible/near-infrared reflectance spectroscopy of Fe-sulfate minerals†

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### ABSTRACT

Sulfate minerals are important indicators for aqueous geochemical environments. The geology and mineralogy of Mars have been studied through the use of various remote-sensing techniques, including thermal (mid-infrared) emission and visible/near-infrared reflectance spectroscopies. Spectral analyses of spacecraft data (from orbital and landed missions) using these techniques have indicated the presence of sulfate minerals on Mars, including Fe-rich sulfates on the iron-rich planet. Each individual Fe-sulfate mineral can be used to constrain bulk chemistry and lends more information about the specific formational environment [e.g., Fe<sup>2+</sup> sulfates are typically more water soluble than Fe<sup>3+</sup> sulfates and their presence would imply a water-limited (and lower Eh) environment; Fe<sup>3+</sup> sulfates form over a range of hydration levels and indicate further oxidation (biological or abiological) and increased acidification]. To enable better interpretation of past and future terrestrial or planetary data sets, with respect to the Fe-sulfates, we present a comprehensive collection of mid-infrared thermal emission (2000 to 220 cm<sup>-1</sup>; 5–45 μm) and visible/near-infrared (0.35–5 μm) spectra of 21 different ferrous- and ferric-iron sulfate minerals. Mid-infrared vibrational modes (for SO<sub>4</sub>, OH, H<sub>2</sub>O) are assigned to each thermal emissivity spectrum, and the electronic excitation and transfer bands and vibrational OH, H<sub>2</sub>O, and SO<sub>4</sub> overtone and combination bands are assigned to the visible/near-infrared reflectance spectra. Presentation and characterization of these Fe-sulfate thermal emission and visible/near-infrared reflectance spectra will enable the specific chemical environments to be determined when individual Fe-sulfate minerals are identified.

**Keywords:** Mid-infrared, visible, near-infrared, spectroscopy, emissivity, reflectivity, sulfate, spectra, reflectance, vibrational, iron, emission, reflectance