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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†

Melissa D. Lane[1,*], Janice L. Bishop[2], M. Darby Dyar[3], Takahiro Hiroi[4], Stanley A. Mertzman[5], David L. Bish[6], Penelope L. King[7,8] and A. Deanne Rogers[9]

[1]Planetary Science Institute, 1700 E. Fort Lowell Road, Suite 106, Tucson, Arizona 85719, U.S.A.
[2]SETI Institute/NASA-Ames Research Center, Mountain View, California 94043, U.S.A.
[3]Mount Holyoke College, South Hadley, Massachusetts 01075, U.S.A.
[4]Department of Geological Sciences, Brown University, Providence, Rhode Island 02912, U.S.A.
[5]Department of Earth and Environment, Franklin and Marshall College, Lancaster, Pennsylvania 17603, U.S.A.
[6]Department of Geological Sciences, Indiana University, Bloomington, Indiana 47405, U.S.A.
[7]Research School of Earth Sciences, Australian National University, Canberra, ACT 0200, Australia
[8]Department of Earth Sciences, University of Western Ontario, London, Ontario, N6A 3K7, Canada
[9]Department of Geosciences, State University of New York at Stony Brook, Stony Brook, New York 11790, U.S.A.

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^{2+} sulfates are typically more water soluble than Fe^{3+} sulfates and their presence would imply a water-limited (and lower Eh) environment; Fe^{3+} 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^{-1}; 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_4, OH, H_2O) are assigned to each thermal emissivity spectrum, and the electronic excitation and transfer bands and vibrational OH, H_2O, and SO_4 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