American Mineralogist, Volume 101, pages 1501–1514, 2016

SPECIAL COLLECTION: MARTIAN ROCKS AND MINERALS: PERSPECTIVES FROM ROVERS, ORBITERS, AND METEORITES

Constraints on iron sulfate and iron oxide mineralogy from ChemCam visible/near-infrared reflectance spectroscopy of Mt. Sharp basal units, Gale Crater, Mars

Jeffrey R. Johnson[1,*], James F. Bell III[2], Steve Bender[3], Diana Blaney[4], Edward Cloutis[5], Bethany Ehlmann[4,6], Abigail Fraeman[6], Olivier Gasnault[7], Kjartan Kinch[8], Stéphane Le Mouélic[9], Sylvestre Maurice[7], Elizabeth Rampe[11], David Vaniman[3] and Roger C. Wiens[10]

[1]Applied Physics Laboratory, Johns Hopkins University, 11101 Johns Hopkins Road 200-W230 Laurel, Maryland 20723-6005, U.S.A.
[2]School of Earth and Space Exploration, Arizona State University, PO Box 871404, Tempe, Arizona 85287-1404, U.S.A.
[3]Planetary Science Institute, 1700 East Fort Lowell, Suite 106, Tucson, Arizona 85719-2395, U.S.A.
[4]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, California 91109, U.S.A.
[5]University of Winnipeg, 515 Portage Avenue, Winnipeg, Manitoba R3B 2E9, Canada
[6]California Institute of Technology, 1200 E California Boulevard, Pasadena, California 91125, U.S.A.
[7]CNRS, Institut de Recherche en Astrophysique et Planetologie, Université de Toulouse, 9 Avenue du Colonel Roche, 31400 Toulouse, France
[8]Niels Bohr Institute, University of Copenhagen, Nørregade 10, PO Box 2177, 1017 Copenhagen K, Denmark
[9]Laboratoire de Planétologie et Géodynamique, Université de Nantes, 2, rue de la Houssinière, BP 92208 44322, Nantes Cedex 3, France
[10]Los Alamos National Laboratory, PO Box 166, Los Alamos, New Mexico 87545, U.S.A.
[11]Johnson Space Center, 2101 NASA Road 1, Houston, Texas 77058, U.S.A.

Abstract

Relative reflectance point spectra (400–840 nm) were acquired by the Chemistry and Camera (ChemCam) instrument on the Mars Science Laboratory (MSL) rover Curiosity in passive mode (no laser) of drill tailings and broken rock fragments near the rover as it entered the lower reaches of Mt. Sharp and of landforms at distances of 2–8 km. Freshly disturbed surfaces are less subject to the spectral masking effects of dust, and revealed spectral features consistent with the presence of iron oxides and ferric sulfates. We present the first detection on Mars of a ~433 nm absorption band consistent with small abundances of ferric sulfates, corroborated by jarosite detections by the Chemistry and Mineralogy (CheMin) X-ray diffraction instrument in the Mojave, Telegraph Peak, and Confidence Hills drilled samples. Disturbed materials near the Bonanza King region also exhibited strong 433 nm bands and negative near-infrared spectral slopes consistent with jarosite. ChemCam passive spectra of the Confidence Hills and Mojave drill tailings showed features suggestive of the crystalline hematite identified by CheMin analyses. The Windjana drill sample tailings exhibited flat, low relative reflectance spectra, explained by the occurrence of magnetite detected by CheMin. Passive spectra of Bonanza King were similar, suggesting the presence of spectrally dark and neutral minerals such as magnetite. Long-distance spectra of the "Hematite Ridge" feature (3–5 km from the rover) exhibited features consistent with crystalline hematite. The Bagnold dune field north of the Hematite Ridge area exhibited low relative reflectance and near-infrared features indicative of basaltic materials (olivine, pyroxene). Light-toned layers south of Hematite Ridge lacked distinct spectral features in the 400–840 nm region, and may represent portions of nearby clay minerals and sulfates mapped with orbital near-infrared observations. The presence of ferric sulfates such as jarosite in the drill tailings suggests a relatively acidic environment, likely associated with flow of iron-bearing fluids, associated oxidation, and/or hydrothermal leaching of sedimentary rocks. Combined with other remote sensing data sets, mineralogical constraints from ChemCam passive spectra will continue to play an important role in interpreting the mineralogy and composition of materials encountered as Curiosity traverses further south within the basal layers of the Mt. Sharp complex.

Keywords: Mars spectroscopy, Mars remote sensing, visible/near-infrared, IR spectroscopy, ferric sulfates, iron oxides, Invited Centennial article