

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

VNIR multispectral observations of aqueous alteration materials by the Pancams on the Spirit and Opportunity Mars Exploration Rovers

WILLIAM H. FARRAND^{1,*}, JEFFREY R. JOHNSON², MELISSA S. RICE³, ALIAN WANG⁴,
AND JAMES F. BELL III⁵

¹Space Science Institute, 4750 Walnut Street, number 205, Boulder, Colorado 80301, U.S.A.

²Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, Maryland 20723, U.S.A.

³Department of Geology, Western Washington University, 516 High Street, Bellingham, Washington 98225, U.S.A.

⁴Department of Earth and Planetary Sciences, Washington University, Campus Box 1169, One Brookings Drive, St. Louis, Missouri 63130, U.S.A.

⁵School of Earth and Space Exploration, Arizona State University, P.O. Box 87104, Tempe, Arizona 85287, U.S.A.

ABSTRACT

Multispectral visible and near infrared (VNIR) observations from the Mars Exploration Rover Pancam multispectral stereo camera systems are consistent with materials having been subjected to various aqueous processes. Ferric oxides in the form of hematite in the Burns and Grasberg formations of Meridiani Planum have been well characterized by Opportunity on the basis of strong 535 and 864 nm absorptions and positive 754–1009 nm and 934–1009 nm slopes. On the rim of Noachian-aged Endeavour crater, Opportunity has observed light-toned veins with high Ca and S, as determined by the rover's Alpha Particle X-ray Spectrometer (APXS), and a negative 934–1009 nm slope in VNIR spectra extracted from Pancam data, indicative of a 1000 nm H₂O overtone absorption. Together these observations indicate that the veins are composed of gypsum. Rocks overturned by Opportunity on the Murray Ridge portion of the Endeavour crater rim display dark- and light-toned coatings. The dark-toned coatings have a red, featureless slope that is consistent with the slope observed in laboratory spectra of high-valence manganese oxide minerals. Potential Mn oxide coatings may also be associated with some exposures of the Grasberg formation. APXS results for high Mg and S in the light-toned coatings of the Murray Ridge overturned rocks and a negative 934–1009 nm slope are consistent with hydrated Mg-sulfates. Opportunity has also observed spectral features in rocks that are consistent with orbital observations of Fe-smectites, as well as Al-smectites and possible hydrated silica in light-toned fracture-fill materials. The Spirit rover observed sulfate-rich light-toned soils exposed by the rover's wheels. Several of these soil observations contained spectral features, such as a broad absorption centered near 800 nm, consistent with ferric sulfate minerals, a finding confirmed by the rover's Mössbauer spectrometer. Spirit also excavated light-toned Si-rich soils. These soils have a flat near-infrared spectrum with a drop in reflectance from 934–1009 nm that is consistent with free water contained in voids or adsorbed onto the surface of the silica.

Keywords: Mars remote sensing, visible/near-infrared, Mars spectroscopy, iron oxides, ferric sulfates, manganese oxides, phyllosilicates