

KILOMETER-SCALE VIS-NIR SPECTRAL VARIATIONS ON MARS FROM GLOBAL MAPPING AND ANALYSIS OF MARS EXPRESS OMEGA DATA. J. F. Bell III¹, E. M. Wolfe¹, B. N. H. Horgan¹, J. Joseph², and S. Araki¹; ¹School of Earth and Space Exploration, Arizona State University, Box 871404, Tempe AZ 85287 (Jim.Bell@asu.edu); ²Cornell University Dept. of Astronomy, Ithaca NY.

Introduction: Remote sensing of Mars reveals significant information about the distribution, mineralogy, crystallinity, oxidation state, and physical properties of iron-bearing materials on its surface [e.g., 1]. Further, assessing and characterizing the inventory of primary ferrous (Fe^{2+}) iron-bearing minerals like pyroxene and olivine and their potential weathering products—secondary ferric (Fe^{3+}) iron-bearing minerals like hematite or goethite, provides a window into the history of alteration and perhaps even past environmental conditions. Global-scale telescopic remote sensing searches for specific absorption features have been partially successful, revealing a strong and relatively featureless near-UV to red reflectance increase characteristic of the presence of nanophase ferric oxides [e.g., 2, 3] and a broad "1 micron" absorption feature characteristic of pyroxene and/or olivines in low albedo areas [e.g., 4-6], but at many tens to hundreds of km per pixel spatial resolution.

Higher spatial resolution studies using the Mars Express OMEGA spectrometer visible to short-wave NIR wavelength channel (OMEGA-VNIR: 350 to 1000 nm; [7]) have provided more specific identification and mapping of ferric oxide (red hematite) absorption features in Valles Marineris and Meridiani Planum [8-10], demonstrating the ability of OMEGA observations to detect such phases locally at resolutions of 300 m to 4 km/pixel scale. Indeed, an initial global-scale search for ferric, ferrous, and hydrated mineral absorption features at that spatial scale using the first 2 years (2004-2005) of OMEGA-VNIR and short-wave near-IR (SWIR) data [11] revealed global patterns of ferric and ferrous absorption features generally consistent with prior global-scale telescopic observations [12].

New Analyses: We are working to expand significantly previous global OMEGA studies [e.g., 12] using the full PDS-released 2004-2011 OMEGA data set, which covers much more of the planet at resolutions at and below 1 km/pixel than have been published previously. The full OMEGA data set provides near-global coverage at 0.3 to 4.0 km/pixel spatial resolution, from 350 to 5100 nm wavelength. We are specifically concentrating on the 350 to ~1300 nm region because of the presence in lab data in that wavelength range of features diagnostic of crystalline ferric oxides, oxyhydroxides, and oxyhydroxysulfates like hematite, goethite, jarosite, schwertmannite, ferrihydrite, and others [e.g., 13, 14].

Methods. We are calibrating, map projecting, and mosaicking the OMEGA data globally at 1 km/pixel scale on a quadrangle-by-quadrangle basis. We use tools designed by the OMEGA team for basic calibration of the data (available on the European Space Agency's Planetary Science Archive Web site: <http://www.rssd.esa.int/index.php?project=PSA>), including the SOFT03 package of IDL programs for extracting raw data, calibrated (I/F = radiance factor) data, and associated calibration information [7]. We developed in-house IDL tools for sorting candidate image cubes, removing bad spectral pixels, removing the solar and atmospheric spectral contributions, creating mapped mosaics, and calculating various spectral parameters [15]. To minimize the effects of atmospheric absorptions, we use an atmospheric absorption model based on the OMEGA team's "volcano scan" method [16]. While the model appears to do an excellent job of removing atmospheric CO_2 and CO features in the near-IR, it is not critical for our primary application that the correction be perfect, because atmospheric gas opacity has little effect on OMEGA-VNIR spectra in the 350 to 1100 nm region or OMEGA-SWIR spectra in the 1000 to ~1300 nm region. Because the VNIR and SWIR spectra overlap near 1100 nm but are not observing *exactly* the same spot on the surface [7, 11], there is often a radiance mismatch between the VNIR and SWIR data of the same pixel. We combine the two spectral ranges by scaling non-atmospherically corrected VNIR spectra to match the value of the atmospherically corrected SWIR spectra near 1100 nm, as long as the scaling factor would be less than a small user-defined value, typically set to 5% to 10%. If multiple input data sets for that mapped (lat,lon) position are available, our software searches for the data set that would yield the smallest VNIR to SWIR scaling factor. To obtain an estimate of the surface albedo, we apply a Lambertian phase function correction to the calibrated I/F data by dividing the spectra by the cosine of the incidence angle for each pixel. Although a Lambertian correction may not be the most rigorous treatment for the surface phase function [e.g., 17], it is the simplest solution to implement, given the uncertainties in the derivation of viewing angles for each pixel. Any mineralogic interpretations derived from this data set will not depend critically on the details of this photometric correction. Additional details of our processing methods are published in [15].

Once calibrated and map projected/mosaicked, we create diagnostic spectral parameter maps (ratios, band depth maps, spectral slope indices) for each quadrangle, based on parameters shown previously to be diagnostic of specific ferric and ferrous minerals [e.g., 12, 18-20]. We use GIS-oriented tools like JMARS [21] to compare the strength and distribution of these features with previous images and maps of the geology, topography, thermal inertia, and TES- and CRISM-derived mineralogy of these regions and place the observed OMEGA iron mineral distribution into a broader geologic and mineralogic context. Goals of our analyses are to test specific stratigraphic-mineralogic relationships [e.g., 22] and to test the hypothesis that these alteration minerals are bulk/bedrock surface components, rather than just coatings or aeolian drifts. Our expectation is that OMEGA results will provide complementary information to these other data sets/results, and will help to guide future MRO/CRISM-based multispectral survey mode (100-200 m/pix) analyses.

Results to Date: Our methodology has allowed us to begin "production mode" processing of all of the released OMEGA data, and we have created approximately half of the USGS Mars quadrangles MC-1 to MC-30. Figure 1 shows an example of our mapping results for the MC-18 Coprates quadrangle, displayed as an RGB composite of OMEGA images at 752, 529, and 409 nm. The resulting OMEGA spectra are relatively continuous across the "1 micron" region, an im-

provement over many previous studies that had to treat and model the VNIR and SWIR spectral regions separately. During the meeting we will present and discuss the interpretation of spectral parameters mapped from these and other newly-mapped OMEGA quadrangles.

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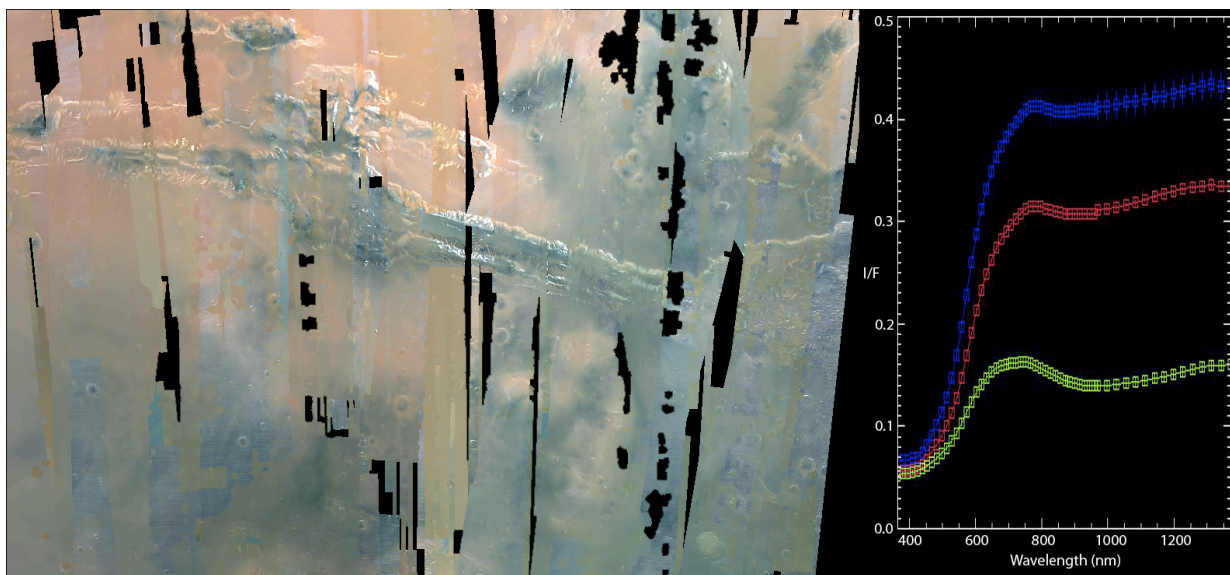


Figure 1. (Left) Example of the current calibrated and mapped USGS Coprates quadrangle (MC-18) image cube using our OMEGA mapping software tools. Each pixel in the map is from OMEGA input data with an input resolution of 2500 m/pixel or better, resampled to 1000 m/pixel. (Right) Example of representative high, intermediate, and low albedo OMEGA spectra from this Coprates image cube, showing the excellent merging of OMEGA-VNIR (below 1000 nm) and OMEGA-SWIR (above 1000 nm) data obtained by our mapping and processing methods.