

SUPPLEMENTARY MATERIAL

Spectral Processing Details

We have analyzed Mars Express OMEGA visible (0.36-1.07 μm ; 96 channels) and near-infrared (NIR; 0.93-2.5 μm ; 113 channels) spectra from the first year of OMEGA observations above 45°N (Bibring *et al.*, 2005). The region was split into a north polar map above 70°N and four quadrangles between 45-70°N, split at 0, 90, 180, and 270°E. All maps were made using stereographic projections centered on the midpoint of the mapped area. The maps were limited to surface observations taken at phase angles <70° to minimize high-phase effects, and between $L_S=90-180^\circ$ to minimize surface frost. Spectra above 70°N were further restricted to $L_S=90-135^\circ$ to minimize north polar hood clouds.

All spectra were calibrated to I/F using standard OMEGA calibration routines (Bellucci *et al.*, 2006), and the NIR channels were atmospherically corrected using the volcano scan algorithm (*e.g.*, Langevin *et al.*, 2005; Horgan *et al.*, 2009). Visible and atmospherically-corrected NIR spectra were separately converted to albedo (assuming a simple Lambertian phase function) and projected using each spectrometer's individual pointing information before being joined at 0.97 μm . Many OMEGA spectra exhibit poor alignment between visible and NIR spectra even after the above corrections, especially bright surfaces and those close to strong albedo boundaries. Because several of the spectral parameters discussed below are sensitive to the relative difference between visible and NIR albedos, spectra with poor alignments (>3% offset) were not included in the final mosaics. Spectra with minor offsets (<3%) were adjusted to improve alignment by linearly scaling the visible channels to match a value projected at 0.96 μm from adjacent NIR channels. To minimize the amount of atmospheric and surface dust contamination, each spectrum included in the final mosaics was chosen from the lowest albedo at 0.75 μm out of all available spectra at each location. After construction of the mosaics, saturated, null, and known bad channels (Bellucci *et al.*, 2007) were replaced with interpolated values.

In order to analyze the 1 μm band in the OMEGA spectra, first we must suppress contributions to the spectra from systematic instrumental and atmospheric artifacts, atmospheric and surface dust, and the overall continuum slope. The former two contributions may be suppressed by ratioing the spectra to a nearby "reference" area that shows little or no relevant spectral contrast, such as a dusty plains region (*e.g.*, Bibring *et al.*, 2005; Langevin *et al.*, 2005). Here, we have used an average of bright spectra (0.3-0.35 estimated Lambert albedo at 0.77 μm) from each mapped region as reference spectra to suppress these effects. While this approach would not be appropriate for identifying narrow spectral features, we are focusing on broad features in smoothed spectra. Furthermore, many of the individual images in our maps are relatively dust-free and therefore do not contain appropriate reference spectra, so we have been able to produce greater consistency between images by using a regional average.

Once the dust contribution is suppressed or removed, the overall continuum shape for most spectra is then dominated by the wings of the 3 μm water band, which cause a downturn at

longer wavelengths. For simplicity, we model this downturn as a second order polynomial. Spectra with strong concave slopes have an additional component to their continua that is modeled well by a power law function with an exponent typically between -4 and -2, similar to Rayleigh or Tyndall scattering (*e.g.*, Guang He *et al.*, 2009). Combining these models gives the following continuum function:

$$\text{Continuum} = ax^b + bx^2 + dx + e \quad (2)$$

where a is positive and $-7 < b < 0$. This continuum function is fit to channels between 0.75-0.96 μm and channels near 1.65 and 2.3 μm . Once the ratioed spectrum is divided by the continuum function, the only remaining features are absorption bands. To further reduce noise and to emphasize broad iron absorptions, all spectra were smoothed with a boxcar smoothing algorithm with a width of $\sim 0.06 \mu\text{m}$, which is equivalent to 10 channels in the visible and 5 channels in the near-infrared. Smoothed spectra are represented by solid lines in Figure 1 of the main text.

References

- Bellucci, G. *et al.*, 2002, OMEGA/Mars Express - Visual channel performances and data reduction techniques: Planetary and Space Science, v. 54, p. 675-684.
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