

due to magmatic intrusions propagating from Alba Patera during the early Amazonian. The dunes of Olympia Undae would not have been involved in the deposition of the sulfates in this model, but rather would have exposed the sulfates from the substrate via aeolian excavation [Tanaka, 2006; Tanaka et al., 2008]. This hypothesis is supported by the presence of features suggestive of mud volcanism, pingo-like extrusions, and phreatic or cryoclastic eruptions in the Scandia unit [Tanaka et al., 2003; Tanaka, 2005].

[32] One of the most puzzling aspects of the question of deposition mechanisms for the sulfate deposit is the timing of deposition. On the basis of OMEGA and Mars Express High Resolution Stereo Camera (HRSC) observations, the most widespread period of sulfate genesis in and around the Valles Marineris region may have been during the early to mid-Hesperian [Bibring et al., 2006]. If the Olympia Planitia gypsum was created by the interaction of some form of H₂O with the Olympia Undae dunes, and the dunes are in fact Amazonian in age, then the north polar sulfate deposit does not correlate with the putative ages of sulfate deposits elsewhere. However, if the dunes are not involved in the genesis of the sulfates, and instead the sulfates are sourced from a much older unit, then this aspect of the geologic history of the north polar region may be more consistent with the Bibring et al. [2006] interpretation of the geologic history of Mars and the Tanaka [2006] hypothesis for gypsum exhumation.

3.4. Olympia Undae Ferrous Materials

[33] Aeolian bed forms on Mars are dominantly composed of dark sand grains, which are basaltic in composition based on remote sensing and in situ observations [e.g., Bell et al., 2004; Bibring et al., 2005; Christensen et al., 2000, 2004b; Gellert et al., 2004; Morris et al., 2006; Rogers and Aharonson, 2008]. Previous workers have classified the Olympia Undae dunes as the lowest albedo and lowest thermal inertia dune field on the planet [Thomas and Weitz, 1989; Herkenhoff and Vasavada, 1999], possibly implying that the erg has undergone unique processes and has a distinct composition as compared to other Martian dune fields.

[34] Bell et al. [1997] identified a strong 953 nm absorption restricted to the circumpolar dark deposits in near-infrared Hubble Space Telescope (HST) multispectral images of the north polar region, implying a strong mafic component to the dunes, most likely a pyroxene. Initial analysis of TES observations by Noe Dobrea and Bell [2001] also suggested a strong pyroxene component to the dunes. OMEGA observations have suggested minor amounts of pyroxene in Olympia Planum [Fishbaugh et al., 2007]; however, these detections are largely confined to localized areas outside the main dune field.

[35] Olympia Undae has since been identified as one of the strongest TES surface type 2 (ST2) [Wyatt et al., 2004] signatures on the planet [Ruff and Christensen, 2007]. TES ST2 may be a primary volcanic lithology or an alteration product, possibly in the form of a rind. Wyatt [2007] have suggested that the differences between the elemental chemistry implied by deeper-probing Mars Odyssey Gamma Ray Spectrometer data and the TES observations in the northern plains implies that the TES ST2 is a surface coating. Although the exact mineralogy of TES ST2 is still in question, intermediate plagioclase and/or a high silica

amorphous phase are strong candidates [Ruff and Christensen, 2007].

4. Methods

4.1. Data Calibration and Reduction

[36] Tools designed by the OMEGA team for basic calibration of OMEGA data are available on the European Space Agency's Planetary Science Archive Web site (<http://www.rssd.esa.int/index.php?project=PSA>). We have used the SOFT03 package, released in October 2005. This package contains IDL programs for extracting raw data, calibrated (I/F) data, and associated calibration information [Bellucci et al., 2006]. We have developed in-house tools for sorting candidate image cubes, removing bad spectels (spectral pixels), removing the solar and atmospheric spectral contributions, creating mapped polar mosaics, and calculating band depth, as discussed below.

[37] A recurrent problem in the majority of these image cubes is the presence of planes of bad pixels 15 pixels wide in the horizontal spatial coordinate, between columns 81 and 96. The bad pixels are either saturated or null, and are confined to alternating pixels in the vertical spatial direction in a fairly consistent pattern (electronic error) [Bellucci et al., 2006]. For the sake of continuity in our final mosaic, we have removed the bad pixels by replacing each bad pixel with the average of pixels above and below at every wavelength, producing a relatively seamless image without significant spectral errors.

[38] To compensate for atmospheric absorption, we have employed an atmospheric absorption model based on the model created by the OMEGA team [Langevin et al., 2005a; E. Z. Noe Dobrea et al., manuscript in preparation, 2009]. In this model, the opacity of the atmosphere between 1.1 and 2.5 μm was empirically derived from the ratio of OMEGA spectra of high and low elevation regions on Olympus Mons (20.9 km and -2.8 km altitude above the ellipsoid), specifically from image ORB0479_5. The atmospheric spectrum for each pixel was then derived by modeling the surface spectrum between 1.954 and 2.010 μm (within the strong CO₂ bands) as a function of the atmospheric opacity and applying the derived model to the rest of the spectrum. Because the 2 μm CO₂ bands vary with atmospheric pressure, the model accounts for elevation changes [Langevin et al., 2005a; E. Z. Noe Dobrea et al., manuscript in preparation, 2009]. Unfortunately, atmospheric spectra created using this method do not accurately model the strong upper atmospheric "hot bands" centered at 1.911 μm and 2.177 μm , as the bands are removed in the ratio. Fortunately, these bands are narrow enough that they only strongly affect one spectel, and we remove them by interpolating across each spectel.

[39] We have applied this model to the OMEGA spectra taken with the short-wavelength infrared channel (SWIR), which includes our wavelengths of interest between 0.93 and 2.5 μm . We have assumed that atmospheric gas opacity has had little effect on spectra taken with the visible and near-infrared channel (VNIR), which includes wavelengths between 0.38 and 1.05 μm , and have not applied a correction to the spectra in that range. Because the spectra overlap at 1.1 μm , we have combined the two spectral ranges by scaling nonatmospherically corrected VNIR spectra to match the value of the atmospherically corrected SWIR spectra at 1.1 μm .