Mars Express OMEGA Observations Over Terra Meridiani R. E. Arvidson[1], F. Poulet[2], J.-P. Bibring[2], M. Wolff[3], A. Gendrin[2], R. V. Morris[4], J. J. Freeman[1], N. Mangold[2], G. Bellucci[5] and The OMEGA Science Team, [1]Department of Earth and Planetary Sciences, McDonnell Center for the Space Sciences, Washington University, St. Louis, Missouri, 63130, arvidson@wunder.wustl.edu, [2]IAS, University of Paris, Paris, France, [3]Space Science Institute, Boulder, Colorado, [4]Johnson Space Center, Houston, Texas, [5]INAF-IFSI, Rome, Italy.

Introduction: The OMEGA hyperspectral imager (0.35 to 5.08 micrometers) covered the hematite-bearing plains and underlying etched terrains of Terra Meridiani during several orbits with spatial resolutions ranging from several hundred meters to approximately 2 km [1]. We extracted and analyzed surface reflectance spectra from OMEGA data for the approximately 864,000 square kilometers surrounding the Opportunity site. In this paper we focus on analysis of OMEGA orbit 485 data for the plains and etched terrains located to the northeast of the Opportunity landing site (Fig. 1).

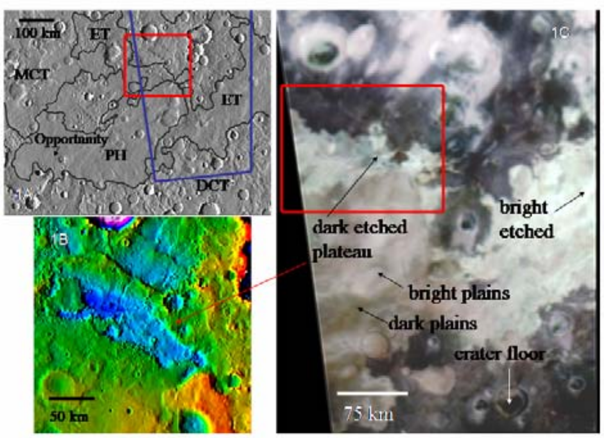

Figure 1: Upper left: MOLA-based shaded relief map showing hematite-bearing plains (PH), etched terrain (ET), dissected cratered terrain (DCT), mantled cratered terrain (MCT), Opportunity site, footprint (blue) for Orbit 485 coverage, and location of detailed MOLA map (red box). Lower left: MOLA detailed shaded relief map color-coded with elevations (red=high; blue=low). Right: OMEGA false color IR composite showing end-member units and locations of color-coded shaded relief map.

Methodology: OMEGA data were reduced to Lambert normal albedos through the use of a multiple scattering code that modeled atmospheric aerosol (and Rayleigh) scattering and molecular absorption. The retrieved surface reflectance values were derived under the assumption of a diffuse (Lambert) surface phase function. For wavelengths longer than 2.5 µm additional terms in the model included thermal emission of the surface and atmosphere. Atmospheric temperature and pressure profiles, together with the dust opacity used in the models, were derived from a combination of Opportunity Miniature Thermal Emission Spectrometer and TES observations acquired close in space and time to acquisition of OMEGA data.

Five spectral end-members explain 86% of the variance for plains, etched terrains, and surrounding dark cratered terrains: a bright etched spectrum typical of the signatures for etched terrain, a dark etched plateau spectrum representative of signatures associated with the northwest-southeast trending valley and plateau, both bright and dark plains spectra, and a dark crater floor spectrum (located in the cratered terrain) (Fig. 1).

Results: Examination of MGS Mars Orbital Camera and Odyssey Thermal Imaging System (THEMIS) image data of the bright plains spectral end-member shows that the material represented by this end-member is located on hematite-bearing, mottled plains. In some locations layering is exposed along cliffs. On the other hand, the dark plains end-member is representative of the spectral signatures for slightly rolling, smooth plains with homogeneous brightness. Bowl-shaped craters are present and well preserved. No exposed layering is evident. Additionally, the bright plains spectrum has a similar shape but lower overall reflectance as compared to the bright etched spectral end-member. We interpret the spectral similarity between bright plains and etched end-members, and the appearance of the bright plains, as indicative of wind erosion and exposure of some etched terrain material in the these areas, with a partial cover of hematite-bearing spherules and basaltic sands similar to what was found at the Opportunity site, several hundred kilometers to the southwest. The dark plains spectral end-member is spectrally flat from ~1.3 to 2.6 µm and has a spectral shape similar to coarse-grained gray crystalline hematite measured in the laboratory. These plains are interpreted to be covered with an areally uniform aeolian lag deposit of hematite-bearing spherules and basaltic sand formed as the plains were slowly eroded by wind.

The deep band at ~3 µm in all spectra results from the well-known O-H stretching fundamental vibrations of the water molecule H_2O (ν_1 and ν_3) [*2*]. This feature has been previously detected from analysis of data from other instruments, including over Terra Meridiani [*3*]. Based on laboratory studies less than 4% adsorbed and/or bound water is needed to produce the magnitude of the observed absorptions [*4,5*]. The feature at 1.92 µm is well expressed in the spectra for etched terrains and is diagnostic of the presence of the H_2O molecule. It results from the combination of the O-H stretching and H-O-H bending fundamental vibrations (ν_2+ν_3) [*2*]. The strength of the ~3 and 1.92 µm features for the etched terrain spectra implies that materials exposed in these deposits are preferentially hydrated relative to the other units for which spectral end-members were extracted. The best match to the spectrum for the dark etched plateau in the 2.0 to 2.5 µm region is the mineral kieserite, $MgSO_4{\cdot}H_2O$. The bright etched terrain spectral features in this region can be interpreted as a combination band of water arising from the coupling of a librational mode with an internal vibration. This band is found in the IR spectra of condensed water and minerals with waters of hydration.

Comparison of OMEGA and THEMIS data shows that the plateau region with the kieserite signature is located between two deposits of the more typical bright etched terrain. Further, the kieserite-bearing surface exhibits a set of domes that is not typical of the rest of the valley and plateau system. The domes appear to be a consequence of preferential cementation of materials by ground water preferentially flowing along fractures. Subsequent differential wind erosion left these regions as local domes because of their indurated nature. In fact, examination of THEMIS data for all the etched terrains evident in Orbit 485 suggests that preferential cementation along fractures followed by differential erosion to produce ridges and plateaus was a common occurrence.

Implications: Our results complement the analyses conducted by the Opportunity rover on the bright layered rocks in Eagle and Endurance craters, where evidence for hydrated sulfate minerals was also found, including kieserite [6,7]. It is our conclusion that Opportunity examined the upper section of the etched terrain deposits in these craters and that our results imply that aqueous processes were involved in forming and/or altering the etched terrain materials over distances of hundreds of kilometers and throughout the several hundred meter thickness of the etched terrain deposits.

References: [1] Bibring J.P. et al. (2005) *LPS XXXVI*, submitted. [2] Herzberg G. (1945) Molecular spectra and molecular structure. II. Infrared and Raman spectra of polyatomic molecules. Van Nostrand Reinhold Company NY. [3] Baldridge A.M. and Calvin W.M. (2004) *JGR*, 109**,** 10.1029 / 2003JE002066. [4] Yen A.S. et al. (1998) *JGR*, 103**,** 11,125. [5] Milliken R.E. and Mustard J.F. (2005) *LPS XXXVI*, submitted. [6] Squyres S.W. et al. (2004) *Science*, 306**,**1698-1703. [7] Christensen P.R. et al. (2004) *Science*, 396, 1733-1739.