Mars surface compositional units and some geological implications from the Mars Express High Resolution Stereo Camera (HRSC)

T. B. McCord (1), J. B. Adams (2, 1), G. B. Hansen (2, 1), J-P. Combe (1,3), G. Bellucci (4), R. Jaumann (5), G. Neukum (6), F. Poulet (7), and A. R. Gillespie (2, 1).

(1) Space Sci. Inst., Bear Fight Center, Winthrop WA, (2) U. of Washington, Seattle, WA, (3) Lab. de Planet. U. de Nantes, Fr, (4) Inst. di Fisica dello Spazio Interpl., CNR, Rome, (5) German Aerospace Center, Inst. of Planet. Res., Berlin, (6) Inst. Of geosci., Freie U. Berlin, (7) Inst. d'Astrophys. Spatiale, U. Paris-Sud, Orsay, Fr.

mccordtb@aol.com

We explored through spectral analysis the surface unit mapping capabilities of the HRSC color data and coupled these with surface feature identification from the high resolution nadir channel and topography from the stereo capability (1). One result is important new information about Mars geology. Deriving reflectance in each color channel for each pixel involves using the radiometric calibration for the instrument and then removing the effects of the Mars atmosphere and the lighting and observation geometry for each color channel pixel. The atmospheric effects due to the different viewing geometry for each channel are complex so after correcting for sun angle we first assumed that the reflectance of one surface unit is known and adjusted the HRSC spectrum accordingly. We selected the dark deposits, which we assumed to be basalt. This produces reasonable results for all scenes studies so far, both polar and equatorial. The reflectance values for each color channels for a pixel on Mars define a four-dimensional data space that contains all possible spectra. We explored this space without using the "basalt correction" for a number of HRSC scenes and Mars regions. Using the approach of spectral mixing analysis, we find that the basic spectral types (which we interpret to be dark rock, red rock, and polar ice) plus shade/shadow are the basic four types that, with their mixtures, represent most of the Mars surface that we have so far analyzed. Other, minority materials, such as salts, are implied but not proven by vectors lying off these mixing lines. We used these definitions to map spectral types for geologic interpretation. For example, the red and dark spectral types define two main geological units in the Valles Marineris region. The red unit dominates the plains that surround the canyons, the upper parts of the canyon walls, and some of the islands within the larger chasmata. Local outcrops of the red unit occur within the dark unit on the valley floors. The dark unit makes up most of the floors of the larger chasmata, where it occurs as extensive smooth plains, occasional dunes and uncommon layered deposits. It also occurs in conical depressions within the red unit, as talus slopes, and in a wide variety of irregular patches. The dark unit is locally present on the high plains near the rims of the chasmata. Although the red unit is topographically above the dark unit on a regional scale, the contact between the two is nearly everywhere broadly gradational, and, locally, dark material appears to have intruded and altered the red unit. The red, high-albedo deposits within the chasmata are spectrally indistinguishable from the materials that comprise canyon walls, rims and the surrounding plains. If these materials all have approximately the same composition, the interior deposits may be part of the Hesperian/Noachian "basement" that comprises the canyon walls and plains, rather than younger deposits that lie unconformably on the basement as previously proposed, e.g., (2). Many workers have lumped the low-albedo materials in the chasmata together with the high-albedo materials as part of the younger, interior deposits. Our spectral definition of units, however, indicates that the dark-material unit is compositionally distinct from the red, high-albedo material. Layers of the dark unit are present in the deepest parts of Mellas Chasma and may be stratigraphically below the red unit. We find no evidence that the red unit occurs stratigraphically below the dark unit, as would be implied if the Hesperian/Noachian basement materials had been down-faulted to form the floor on which younger, dark materials were deposited. Excluding dunes and dust deposits, the main interface between the red and the dark units in the chasmata is morphologically complex and extends over an altitude range of several kilometers. Furthermore, the contact is everywhere gradational. If the dark material is basaltic in composition, it is difficult to explain the observed complex and gradational zone as a depositional contact between dark flows/tephra and overlying lighter deposits. On the other hand, it does not appear that the dark unit is simply intrusive into the red one, although in places there is evidence that the dark material has followed fracture zones into the high-albedo material and can be seen in the chasmata walls. We are exploring alternative hypotheses for the stratigraphy of Valles Marineris, We suggest that understanding the interface between the red and dark units is essential for understanding the origin of the Valles Marineris region.

References: [1] McCord T. B., et al. (2006) JGR, submitted. [2] Witbeck et al., (1991) U.S.G.S, Misc. Investigation Series, Map I-2010.