A RE-ASSESSMENT OF GLOBAL COLOR UNITS ON MARS FROM HUBBLE SPACE TELESCOPE VISIBLE TO NEAR-IR IMAGING AND SPECTROSCOPY. J.F. Bell III1, R.V. Morris2, W.H. Farrand3, and M.J. Wolff4; 1Cornell University, Department of Astronomy, Ithaca NY (jfb8@cornell.edu); 2NASA Johnson Space Center, Code SN3, Houston TX; 3Space Science Institute, Boulder CO.

Introduction: We are using new multispectral imaging and imaging spectroscopic measurements of Mars from the Hubble Space Telescope (HST) to identify and map Mars surface color and spectroscopic units globally at scales of ~20 to 50 km/pixel. Results from observations in 1999 reveal additional spectral heterogeneity beyond that which was detectable using Viking Orbiter 3-hand visible imaging [1,2]. Specifically, variations in surface spectral properties from 750 to 1000 nm provide significant additional discrimination of surface units based on variations in crystalline ferric and ferrous mineralogies.

Background: Mars is proving frustratingly difficult to characterize mineralogically. This partly results from limitations of the remote sensing methods used historically to attempt to determine the composition and mineralogy of the surface, and from the nature of the surface and the surface/atmospheric environment itself. For example, groundbased telescopic observations can typically achieve spatial resolutions of only 150-250 km at best, and only for short periods of time around Earth-Mars oppositions [e.g. 3,4]. The resulting spatial averaging of surface spectral units dilutes the signatures of small geologically (and perhaps mineralogically) interesting regions of the surface, and has led to the misconception that the planet is covered by a ubiquitous and homogeneous layer of global dust. In fact, the highest spatial resolution groundbased observations obtained to date have revealed evidence for mineralogic variability at the smallest observational scales [e.g., 4-8]. Previous orbital spacecraft investigations have been limited by inadequate spectral sampling or spectral resolution for mineralogic studies (Viking missions), limited spatial coverage and/or calibration uncertainties (Mariners 6, 7 and Phobos-2), or out and out failures (MO, MCO). Some data from the Phobos-2 ISM instrument provides evidence for interesting near-infrared spectral unit variability on the ~20 km/pixel scale, and this has been interpreted in terms of variations in ferric (Fe$^{3+}$), ferrous (Fe$^{2+}$), and hydrated mineralogies [9-12]. Complementary studies of previous multispectral images from HST at shorter wavelengths and at slightly coarser spatial scale (25-50 km/pixel) also show evidence for spectral unit variability that is related to ferric and ferrous mineralogy [13-14]. And most recently, mapping observations by the MGS-TES instrument in the mid-infrared at a spatial scale at or below ~10 km/pixel is revealing new details of the surface mineralogy, specifically for particle size regimes and/or compositions that do not exhibit diagnostic or detectable near-IR spectral properties [e.g., feldspar, coarse-grained hematite; 15-18]. It seems apparent that although variations in Martian surface mineralogy are not screaming out at us in these best-available datasets, the details are slowly being teased out because of steady improvements in spatial resolution, spatial coverage, spectral resolution, spectral modeling tools, and data/calibration quality.

In that spirit, we are analyzing recently acquired HST images of Mars and globally mapping the major visible to near-IR color units on the planet. In essence, we are re-doing the pioneering Viking global spectral unit analyses of Soderblom et al. [1] and McCord et al. [2] at a comparable spatial scale and geographic extent, but with greatly improved spectral coverage, dynamic range, and spectral analysis tools.

Datasets: Our primary dataset consists of 48 HST/WFPC2 images of Mars obtained in 12 wavelengths between 255 nm to 1042 nm during the 1999 opposition. The images were all obtained near $L_s$ ~130° and at phase angles below 10° and have been calibrated to I/F to an estimated absolute accuracy of ~2 to 10%. Figure 1 shows examples of the image quality and the geographic coverage obtained during the 1999 opposition. Figure 2 shows examples of 12-color calibrated spectra from the dataset. Secondary datasets still undergoing final calibration and mapping include more than 250,000 HST/STIS spectra of Mars obtained in 1021 channels between 528 nm to 1027 nm (0.48 nm/channel resolution), also during the 1999 opposition, 22 HST/NICMOS images of Mars obtained in 11 wavelengths between 950 nm to 2370 nm on 23 July 1997, and thousands of near-IR images of Mars obtained from the NASA IRTF from late 1996 to mid 1999 as part of a long-term Mars monitoring program.

Results: A combination of analysis techniques [14,19] have been used to classify Mars surface units according to their 12-color spectral character. Preliminary results showing derived spectral unit distributions for bright and dark regions are shown in Figure 3. These results indicate that spectral differences in the 750 to 1000 nm region provide important additional constraints to distinguish among different surface multispectral units. Ongoing work will relate unit boundaries within high and low albedo classes to differences in topography and/or geology, to determine what fraction of the observed variations may be related to viewing geometry vs. compositional differences.
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Figure 3 (below): Overlay of bright region classes on the HST WFCP2 data from (A) 27 April 1999 and (B) 1 May 1999. The most prominent bright regions (as determined from thresholding of a “bright regions fraction image”) are presented in orange. Spectrally distinct classes were determined by partitioning of the first three Minimum Noise Fraction transformed bands [19]. The most spectrally distinct bright region classes are shown here in green, dark blue, and red. The green class, in the bright region Acidalia, is repeatedly identified in independent datasets and at different local times of day. (C) Similar except for dark region classes in (B). The class spectra in (D) reveal significant differences in the near-IR spectral properties between the units identified in Syrtis.


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