COMPARISON OF NEW GROUNDBASED AND PHOBOS-2 VSK COLOR RATIO DATA FOR MARS; James F. Bell III[1,2], Mark S. Robinson[1], Thomas B. McCord[1,3], and Fraser P. Fanale[1] ([1]Planetary Geosciences Division, Univ. of Hawaii, Honolulu 96822; [2]Remote Sensing Lab, Univ. of Washington AJ-20, Seattle 98195; [3]SETS, Inc., Mililani, HI 96789)

Summary: The VSK-FREGAT imaging experiment on the Phobos-2 spacecraft acquired several VIS (0.4-0.61 μm) and NIR (0.7-1.1 μm) image pairs containing both Mars and Phobos during February and March, 1989 [17]. We have analyzed these image pairs and calculated NIR/VIS DN ratios for Mars for comparison with groundbased 0.4-1.0 μm CVF reflectance spectra obtained during August, 1988 [1]. We find that for the particular region imaged (Mare Sirenum, 35°S, 155°W--NE of Newton crater) our telescopic reflectance spectrum convolved to VSK bandpasses yields a NIR/VIS ratio of 1.78. The NIR/VIS DN ratio that we obtained from Phobos 2 image pairs at similar phase angles as the groundbased data is 2.25±0.2, thus suggesting that dividing such Mars (and Phobos) DN ratios by a correction factor of 1.26 yields more accurate values for the true NIR/VIS reflectance ratio. Several sources of error, including near-opposition contrast enhancement in the blue ("blue clearing") associated with possibly variable atmospheric dust loading between August 1988 and February-March, 1989 indicate that this method of calibration could possibly suffer from additional errors of up to 10-15%, although comparison of the Phobos-2 data with Viking results [5] seems to indicate that these effects were minimal or absent during the 1989 encounter.

Discussion: Current efforts to map color variations (and thus perhaps map compositional variations [2,5]) are using calibration methods based on modeled groundbased telescopic narrow-band filter photometer data of Mars (R ≈ 20; [e.g. 3,4]) compared against the spacecraft VIS and NIR image pairs that contain both Mars and Phobos [5]. After having discovered that one of the regions we measured in August 1988 was also serendipitously imaged by Phobos-2 (S. Murchie, personal communication, 1989), we decided to use these new, higher spectral resolution data to better constrain the ongoing color calibration efforts [5,6].

Using the data from [7] we plotted a smoothed solar spectrum for the 0.4-1.1 μm region and multiplied this spectrum by our reflectance data for CVF Spot 88-37 (Figure 1). Thus we obtained a spectrum that we then convolved into the VSK VIS and NIR bandpasses that simulates the response that the Phobos-2 cameras recorded of the same region on Mars some six months later. Ignoring absolute flux levels since we are most interested in obtaining the VIS/NIR channel *ratio* and using a NIR/VIS filter efficiency ratio of 1.395 (B. Zhukov, personal communication, 1989) we determined that if the VSK experiment had been looking at a region on Mars which exhibits a reflectance identical to that of our CVF Spot 88-37, then it would have obtained a NIR/VIS DN ratio of 1.78 (for comparison, [5] obtained NIR/VIS = 2.08). Additionally, we found that given the above parameters and a NIR/VIS bandpass solar flux ratio of 0.806, the NIR/VIS DN ratio of a constant albedo object as viewed by VSK would be 1.125.

Using dark subtracted, flatfielded, and recently re-calibrated [5] VSK images of Phobos and Mars, we determined average DN values and variations for the region of Mars common to our spectral data in images 2300123 and 2300111. Data values for 17X17 pixel regions for the NIR and VIS channels were 62±3.5 and 110±3, respectively. The VIS image had an exposure 4 times that of the NIR, so assuming that the cameras were linear the resulting NIR/VIS image ratio was 2.25±0.19.

A possible source of error in the comparison with groundbased results is the so-called "blue clearing" or near-UV brightening near zero phase. This effect (which is difficult to quantify) is typically strongest during periods near perihelion in southern hemisphere spring and summer (L_S≈160-200° and L_S≈270-300° [8]). Visual monitoring during our telescopic observations, acquired at L_S=250° and a phase angle of 34° did not show any indications of this phenomenon, however imaging spectrometer data that we obtained six weeks later at opposition (near zero phase) did show distinct evidence of increased contrast in the blue [9,10], suggesting that significant changes in reflectivity can occur in global or localized areas on Mars over short timescales. Comparisons of these telescopic spectra (and others such as those of

[3,4]) with the Phobos-2 imaging data, acquired at L_S=3°-17°, may exhibit systematic variations of up to 5-10% due to such variations in flux in the visible.

A related source of variability is atmospheric dust load changes between August 1988 and February-March 1989. Variations in column abundance and/or surficial distribution of bright, very red dust particles (which may be the cause of brightening in the blue) are known to occur on both diurnal and seasonal timescales, with the greatest variability typically occurring near and shortly after perihelion when insolation is a maximum [11,12]. Fe^{3+}-rich dust will produce systematic variations mostly in the Phobos-2 NIR imaging channel due to its higher reflectance from 0.7-1.1 µm than from 0.4-0.61 µm [1,13]. Although difficult to quantify and highly longitudinally dependent, we estimate that variations in dust opacity over a low albedo region such as Sirenum can easily lead to 10-15% reflectance variations at NIR wavelengths for localized dust storms, or possibly up to 50% reflectivity variations during truly global dust storms that completely obscure the surface below [see also 14,15].

The combined effect of these VIS and NIR variabilities on the final NIR/VIS DN ratios is to introduce possibly significant uncertainty (perhaps as much as 10-15%) in the comparison with groundbased reflectance data which have not been simultaneously obtained. Unfortunately, we know of no 0.4-1.1 µm reflectance spectra of Mars obtained during February-March 1989 other than the Phobos-2 ISM imaging spectrometer data [16], which only extend down to 0.8 µm and did not image the Sirenum region. Preliminary work comparing Viking Orbiter and Phobos-2 color ratios of Phobos [5] seem to indicate, however, that these effects may not be serious for these data, thus allowing increased confidence in color unit mapping efforts.

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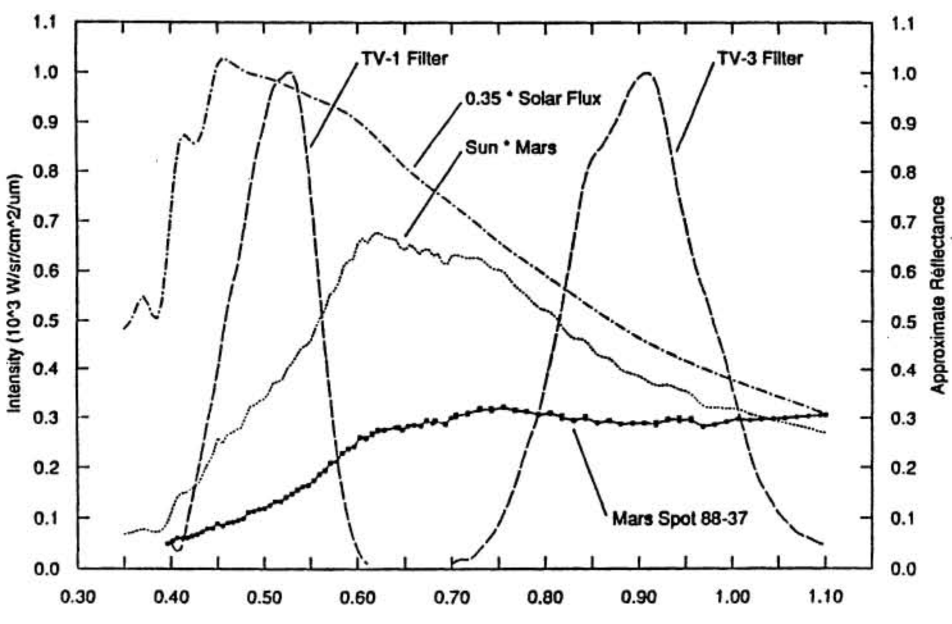

Figure 1: 1988 Mars CVF reflectance data (scale at right), Phobos-2 VSK bandpasses (normalized to 1.0) [17] and Solar Flux [7] and Mars*Solar Flux data (scale at left).