**REGIONAL COLOR PHOTOMETRY OF MERCURY'S SURFACE.**

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**Introduction:** During MESSENGER's first flyby of Mercury, the Mercury Dual Imaging System (MDIS) Wide-Angle Camera (WAC) [1] obtained a set of color images to be used specifically for photometry. Images with each filter (listed in Table I) were obtained of the same target area on Mercury's surface over a 66° to 125° range in solar phase angle. This same target area was imaged during the departure color imaging sequences (at phase angles of 53° to 58°). This phase angle range provided sufficient coverage to examine and compare the photometric properties of different terrain units, as shown in Figure 1.

During MESSENGER's second flyby of Mercury the opposite hemisphere was imaged, and there were no dedicated photometric sequences in the MDIS imaging. However, the principal component maps derived from both flyby encounters show a ubiquitous, spectrally intermediate terrain unit [2] present in both hemispheres. Using the imaging data from both sequences this unit was sampled across the planet, under the assumption that its properties are uniform over the surface. By combining the M1 and M2 data, the phase angle coverage is increased to a range of solar phase angle of approximately 30° to 125°.

**Table I. MDIS WAC Filter Bandpasses [1]**

| MDIS Filter No. | Central Wavelength (nm) | Filter width (nm) |
|---|---|---|
| 6 | 433.2 | 18.1 |
| 3 | 479.9 | 10.1 |
| 4 | 558.9 | 5.8 |
| 5 | 628.8 | 5.5 |
| 1 | 698.8 | 5.3 |
| 7 | 748.7 | 5.1 |
| 12 | 828.4 | 5.2 |
| 10 | 898.8 | 5.1 |
| 8 | 947.0 | 6.2 |
| 9 | 996.2 | 14.3 |
| 11 | 1012.6 | 33.3 |

**Methodology**: A two-fold approach was taken in studying Mercury's photometric characteristics. The first was to use information across the entire target area to obtain a photometric modeling solution to describe the "generic" surface. An accurate photometric model is required for mosaicking map products from both MDIS and the Mercury Atmospheric and Surface Composition Spectrometer (MASCS), because each instrument will acquire global coverage over a range of photometric geometries (MDIS resides on a pivot platform, whereas MASCS is body-fixed within the payload adapter ring). The modeling solutions to this data set provided the necessary photometric corrections for creating the mosaic map products for the MDIS imaging data.

The Visible and InfraRed Spectrograph (VIRS) component of MASCS, which covers the spectral range 320-1450 nm at 5-nm spectral resolution, was used to observe this region over a phase angle range of 85° to 90°. In order to correct the VIRS data set to a common illumination and viewing geometry, a set of photometric corrections is required. The illumination and viewing geometry range of the VIRS data is insufficient to constrain adequately any photometric modeling, so photometric normalizations need to be derived from the MDIS data set and extrapolated to the VIRS spectral range.

The second approach was to examine distinct units, as recognized in principal component images [2] to provide information on the range of variability in the photometric characteristics of Mercury's surface. First, different unit types within the first flyby photometry target area were examined (see Figure 1). These analyses showed subtle variations in scattering properties and single-scattering albedo. Next, samples of the intermediate terrain from both flyby image sets were examined, providing another measure of "generic" Mercury surface photometric properties.

**Current Coverage**: Prior to MESSENGER's flybys of Mercury, photometric observations (defined as reflectance measurements over a range of illumination and viewing geometries) were limited in both spectral and angular coverage. Disk-integrated observations by Danjon [3] and Mallama et al. [4] provided the broadest phase angle coverage (2°-123° and 2°-170°, respectively) but only at a single wavelength (550 nm). Disk-resolved telescopic observations, such as those by Warell [5], have provided a broader spectral coverage (450 to 940 nm) but over a small range of phase (64° and 84°) and emission (-53° to 65°) angles. Mariner 10 images, while providing high-spatial-resolution, disk-resolved coverage, are also limited in wavelength (clear filter, center wavelength 490 nm) and phase angle (40° to 118°, but not of a single area) coverage. MESSENGER provides broad, disk-resolved phase angle coverage (53° to 125°) over a wider wavelength range (430 to 1010 nm) at a single spot on the planet. The combined first- and second-flyby data from MESSENGER provide the broadest spectral coverage (433 to 1012 nm with MDIS, 320 to 1450 nm with VIRS) and the largest range of phase angle (30° to 125°) for disk-resolved observations.

**Analysis**: The Hapke equations [6,7,8] have been applied to photometric observations in attempts to model the photometric reflectance behavior, and to correlate those properties with regolith characteristics such as porosity, roughness, albedo, and particle scattering signatures. The focus, to date, of these Mercury photometric analyses has been to provide a method for correcting to a common illumination and viewing geometry, thus enabling direct color and spectral comparisons between units on Mercury and with laboratory measurements. Figure 2 shows a sample of the results, where the single-scattering albedo is mapped as a function of wavelength, derived from modeling of the MDIS data set. This mapping enables the photometric normalization of the VIRS data for comparison with laboratory measurements of mineral reflectance.

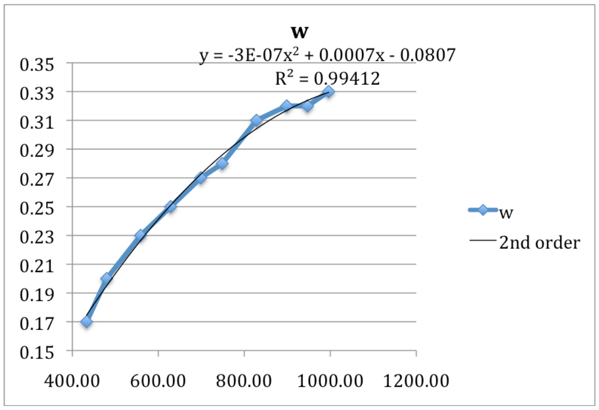


Figure 2. Single-scattering albedo values, derived from photometric analysis of the MDIS images of the photometric target area of flyby 1, as a function of wavelength. Similar analysis and wavelength mapping have been conducted for the other Hapke modeling parameters.

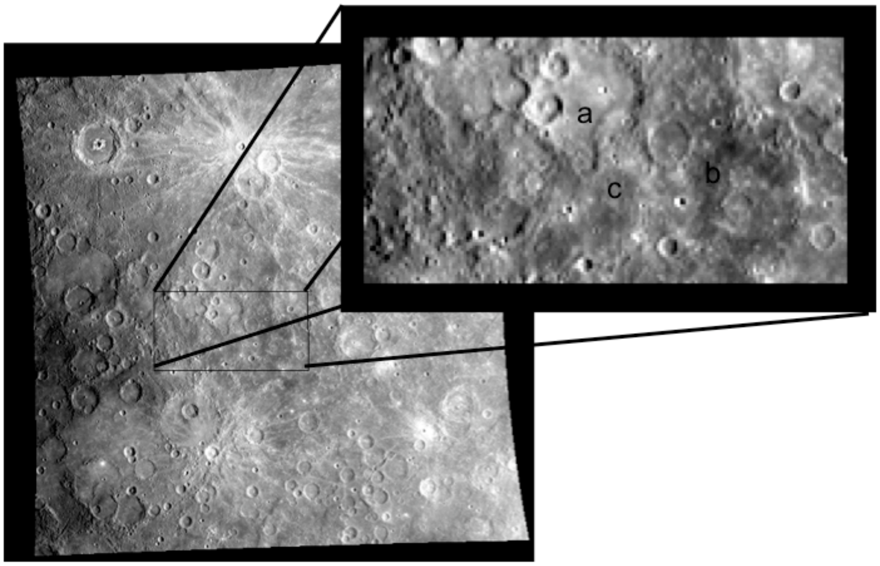


Figure 1. The photometric target area (inset) observed during the first Mercury flyby. The area labeled "a" represents a crater-filling unit (high-reflectance red plains), the area labeled "b" represents a dark, bluish unit (low-reflectance material), and the area labeled "c" is a sample of the more common intermediate terrain.

**References**: [1] Hawkins S. E., III, et al. (2007) *Space Sci. Rev. 131*, 247-338. [2] Robinson M. S., et al. (2008) *Science 321*, 66-69 [3] Danjon A. (1949) *Bull. Astron. 14*, 315-345. [4] Mullama A. et al. (2002) *Icarus 155*, 253-264. [5] Warell J. (2002) *Icarus 156*, 303-317. [6] Hapke B. (1981) *J. Geophys. Res. 86*, 3039-3054. [7] Hapke B. (1984) *Icarus 59*, 41-59. [8] Hapke B. (1986) *Icarus 67*, 264-280.