INTEGRATION OF SURFACE SPECTRA AND MULTISPECTRAL IMAGING DURING THE FIRST MESSENGER FLYBY OF MERCURY.

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Introduction: On January 14, 2008, the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft will conduct a flyby maneuver approaching within 200 km of the planet Mercury. Here we detail the geometry of the maneuver, the relevant observation sequences of the optical remote sensing instrumentation, and the complementary results from surface reflectance spectra and multispectral imaging. Other related abstracts at this meeting discuss an overview of the flyby [1], spectroscopy [2], color imaging [3], color photometry [4], mineralogy [5], and ultraviolet surface reflectance [6].

Background: Mercury is inferred to possess a large iron core, but as yet the evidence for iron in its surface has been elusive. Ground-based spectroscopy has shown that the regolith exhibits optical characteristics similar to the low-iron anorthositic lunar highlands [7, 8]. Interpretation of color variations of higher-resolution Mariner 10 images suggests some compositional variability of the surface, attributed to low-iron volcanism and the heterogeneous distribution of opaque minerals [9]. Both possibilities allow for an investigation into the composition of the Mercury crust through reflectance spectroscopy. This flyby provides the first high-resolution (spatial and spectral) glimpse into understanding the compositional diversity of this planet in preparation for the orbital phase of the mission set to begin in March 2011.

Instrumentation: The MESSENGER spacecraft is equipped with seven science instruments [10]. The Mercury Atmospheric and Surface Composition Spectrometer (MASCS) consists of a Cassegrain telescope that simultaneously feeds the Visible and Infrared Spectrograph (VIRS) and the Ultraviolet and Visible Spectrometer (UVVS) [11]. VIRS is a point spectrometer with a 0.023° field-of view, covering the wavelength range 320-1450 nm at 5-nm resolution in two spectral channels: visible or VIS (320-950 nm), and near-infrared or NIR (900-1450 nm). The UVVS is a scanning grating monochromator with three spectral channels: far-ultraviolet or FUV (115-190 nm), middle-ultraviolet or MUV (160-320 nm), and visible or VIS (250-600 nm). The UVVS has a long-slit entrance aperture which subtends 1° × 0.04° for atmospheric observations and a mechanism to reduce the aperture to 0.05° × 0.04° for surface observations.

The Mercury Dual Imaging System (MDIS) consists of a multispectral Wide Angle Camera (WAC) and a panchromatic Narrow Angle Camera (NAC) [12]. While both channels use identical 1024 × 1024 pixel detectors, the WAC and NAC spatially subtend 10.5° × 10.5° and 1.5° × 1.5°, respectively. The WAC features a 12-position filter wheel: 11 narrow-band spectral filters across the visible plus one wideband navigation filter.

Observations: MESSENGER will approach Mercury from the dark side, passing the 200 km point of closest approach at 38° E longitude on (nominally) 14 January 2008, 19:04 UTC. The spacecraft groundtrack during the surface observations is within 10° of the equator. Owing to spacecraft pointing restrictions, the body-fixed instrumentation (all except MDIS) can view the surface only for about 14 minutes, allowing 677 individual VIRS spectra. A narrow strip of the region within 95° to 190° E longitude and -11° to +3° latitude will be observed (see Fig. 1). The instantaneous VIRS field-of-view is proportional to the distance to the surface. The ground speed of the spacecraft is inversely proportional to the altitude, and the 1-s integration time results in downtrack spatial smearing. Therefore, the spatial resolution of most VIRS scans will range from ~1×4 km to ~3×3 km (crosstrack × downtrack). The VIRS observations will mostly cover the hemisphere not imaged by Mariner 10, but we will also obtain spectra across the smooth plains of Tir Planitia and the intercrater plains northwest of the Tolstoj basin.

NAC panchromatic images of all regions sampled by VIRS will have a spatial resolution of at least 0.5 km/pixel and for some areas as high as 0.1 km/pixel. WAC full-color imaging of these regions will have a spatial resolution of at least 2.5 km/pixel and up to ~1 km/pixel in the area centered at 125° E longitude.

Analysis approach: For any single observation, the MDIS WAC provides large spatial coverage in a selectable bandpass filter, while MASCS-VIRS provides a continuous, high-resolution spectrum for a single spatial point. Therefore, multispectral images from MDIS-WAC provide regional context for the high-spectral-resolution VIRS observations. In addition, VIRS data extend the wavelength coverage into the near-ultraviolet (115 nm) and near-infrared (1450 nm). The continuous spectra from VIRS allow for detailed characterization of mineralogically distinct absorption features.

On July 31, 2005, an orbital maneuver past the Earth provided an opportunity to view the Moon with MESSENGER's remote-sensing instruments [13]. Both color imaging from MDIS-WAC and spectra from MASCS-VIRS were obtained of the 65°-phase Moon, covering the southern hemisphere of the farside. The observations were obtained at a distance of ~950,000 km; thus the spatial resolution was low (~380 km for VIRS). However, the lunar reflectance spectra provide an important comparison to those from Mercury. Contrasting the shapes of the reflectance spectra from these two bodies provides insight into the compositional similarities (or dissimilarities) between them.

In order to provide a seamless intercomparison of data products among the optical remote-sensing instruments, the absolute and relative calibrations must be cross-checked. That is, when observing the same target with both MASCS-VIRS and MDIS-WAC, calibrated VIRS spectra convolved with the multispectral-filter bandpass functions are expected to agree with the derived WAC radiance. MDIS-WAC will conduct a photometric study of the Mercury surface by imaging a fixed region centered at ~125° longitude through all color filters at a variety of lighting conditions [4]. One set of these observations will have a viewing geometry similar to the VIRS drift scans across this region. This dataset will provide an important opportunity to ensure an accurate cross-calibration between the two devices. Calibrated and rectified MDIS images will be sampled within the elongated VIRS footprints and compared with the calibrated radiance spectra. A similar study during the Venus flyby has shown that the calibration agrees to ~10% [14].

Conclusion: The surface reflectance spectra from VIRS and the multispectral imaging from MDIS-WAC provide complementary compositional information during the first Mercury flyby described here and in future flyby and orbital observations.

References:

[1] S. C. Solomon et al. (2008) *Lunar Planet. Sci.* XXXIX. [2] W. E. McClintock et al. (2008) *Lunar Planet. Sci.* XXXIX. [3] M. S. Robinson et al. (2008) *Lunar Planet. Sci.* XXXIX. [4] D. L. Domingue et al. (2008) *Lunar Planet. Sci.* XXXIX. [5] N. R. Izenberg et al. (2008) *Lunar Planet. Sci.* XXXIX. [6] F. Vilas et al. (2008) *Lunar Planet. Sci.* XXXIX. [7] D. T. Blewett et al. (2002) *Meteorit. Planet. Sci.* 37, 1245-1254. [8] J. Warell et al. (2006) *Icarus*, 180, 281-291. [9] M. S. Robinson and P. G. Lucey (1997) *Science*, 275, 197-200. [10] S. C. Solomon et al. (2007) *Space Sci. Rev.*, 131, 3-39. [11] W. E. McClintock and M. R. Lankton (2007) *Space Sci. Rev.*, 131, 481-521. [12] S. E. Hawkins, III, et al. (2007) *Space Sci. Rev.*, 131, 247-338. [13] G. M. Holsclaw et al. (2005) *Eos Trans. AGU, 86, Fall Meeting suppl.*, abstract #P51A-0896. [14] G. M. Holsclaw et al. (2007) *Eos Trans AGU, 88, Fall Meeting suppl.*, abstract #P33B-1292. [15] USGS Map I-1149, 1979.

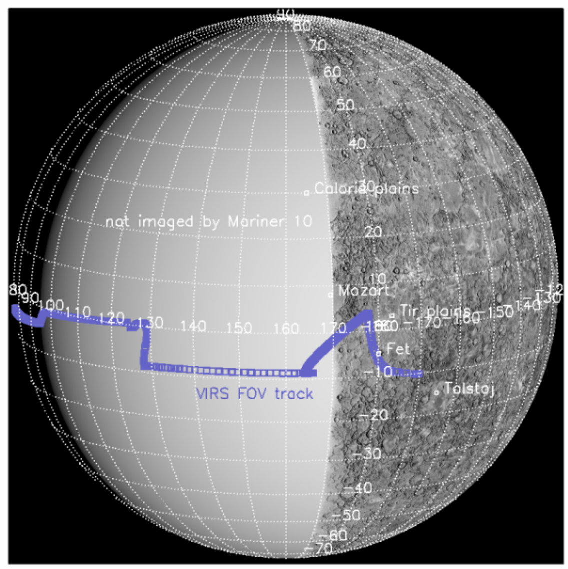

Figure 1 – Simulated orthographic view of Mercury showing the location of the VIRS field-of-view groundtrack during the first Mercury flyby, superimposed on the shaded relief map derived from Mariner 10 imaging [15].