EPSC Abstracts
Vol. 6, EPSC-DPS2011-860, 2011
EPSC-DPS Joint Meeting 2011

Surface Reflectance of Mercury from MESSENGER Orbital Observations

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Abstract

The MESSENGER spacecraft entered orbit around Mercury on 18 March 2011, beginning a year-long investigation of the innermost planet. We present initial findings from the orbital investigation with the spacecraft's surface composition spectrometer, which obtained over 400,000 resolved reflectance spectra of the surface (spanning the wavelength range 320-1450 nm) in the first 10 weeks of orbital operations.

1. Introduction

The MESSENGER spacecraft's [1] Mercury Atmospheric and Surface Composition Spectrometer (MASCS) [2] has been mapping the planet's surface and exosphere from orbit since 29 March 2011 and has obtained more than 400,000 near-ultraviolet to near-infrared spectra of Mercury's surface during the first 10 weeks of operations. The Visible and Infrared Spectrograph (VIRS) channel on MASCS consists of two linear photodiode arrays covering the wavelength range 320-1450 nm. The Ultraviolet and Visible Spectrometer (UVVS) channel consists of three photomultiplier tubes and a scanning grating, covering spectral emissions and surface reflectance over the range 115-600 nm. VIRS has accumulated over 110 orbits of data (Fig. 1), including mapping swaths, geologic targets, and photometric targets. UVVS has observed over a dozen point targets in addition to its exosphere campaign.

2. VIRS Mapping Measurements

Systematic VIRS mapping of Mercury has sampled approximately half the planet. Because of MESSENGER's highly elliptical orbit, individual resolved footprints on the surface have varied resolutions and aspect ratios, from 100 m x 4 km near northern periapsis to 6 x 6 km near southern apopasis.

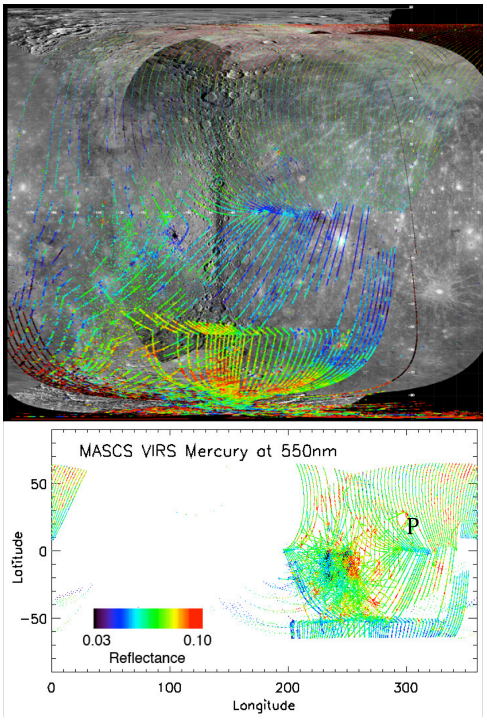

Figure 1: Top: MASCS ground tracks, color-coded by near infrared slope (ratio of reflectance at 700 nm to that at 400 nm), superimposed on Mercury image base map; hotter colors indicate higher ratios. Bottom: Surface reflectance at 550 nm with simple geometric correction for spectra at an incidence angle < 65°. P indicates location of Praxiteles crater.

Thus, coordination and collocation with the Mercury Dual Imaging System (MDIS) [3] base map is critical for context and interpretation. Pointing constraints for spacecraft safety limit surface spectral

observations to a phase angle range from 78° to 102°, meaning that well-illuminated observations are always viewed obliquely at high emission angles, and vice versa. The area of well-illuminated (incidence angle <65°) coverage at 550 nm as of this writing is shown in Fig. 1.

3. Local Variations, Early Analysis

As we work towards a global photometric correction for Mercury, initial analyses focus on local variations, for which illumination and viewing conditions are nearly constant. Fig. 2 shows the crater Praxiteles with VIRS ground tracks superimposed. Praxiteles is one of many craters with interior, bright, spectrally red haloed pits indicative of possible past pyroclastic volcanism [4]. The regional average spectrum (reflectance normalized to that at 450 nm shown in Fig. 3) is typical of Mercury; positive or "red" sloped with no clear diagnostic absorption features.

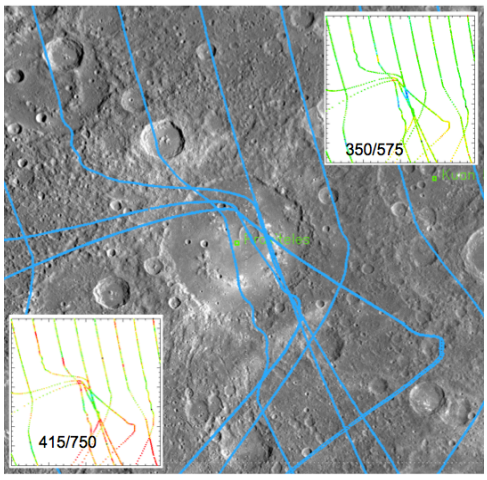

Figure 2: VIRS ground tracks (blue) over Praxiteles crater. Praxiteles is ~200 km diameter. Visible-infrared and ultraviolet-visible slopes are shown in insets. Hotter colors indicate higher ratios of the slopes over the indicated wavelengths (in nm).

Individual VIRS spectra of the floor of Praxiteles differ from the regional mean (10 sample spectra from in and around Praxiteles are shown normalized to the regional mean in Fig. 3); steeper infrared slopes and markedly steeper ultraviolet-visible slopes are possibly indicative of oxygen-metal charge-transfer absorptions (e.g., Fe-Ti). [5].

Analysis of the large and growing MASCS dataset continues. We will discuss additional local variations, photometric normalizations, and comparisons with possible spectral end-members.

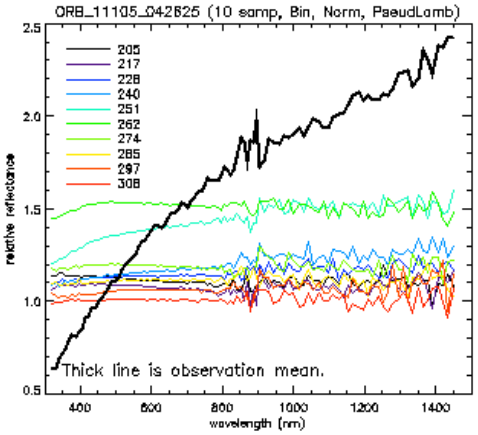

Figure 3: Normalized regional mean spectrum (bold), and relative variation of spectral reflectance in and around Praxiteles. Green spectra are over candidate pyroclastic deposits in the crater interior.

Acknowledgements

The MESSENGER mission is supported by NASA's Discovery Program.

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