ULTRAVIOLET REFLECTANCE SPECTRA OF MERCURY'S SURFACE ACQUIRED WITH THE ULTRAVIOLET AND VISIBLE SPECTROMETER DURING THE FIRST MESSENGER FLYBY. Faith Vilas[1], Ann L. Sprague[2], Noam R. Izenberg[3], William E. McClintock[4], Deborah L. Domingue[3], Gregory M. Holsclaw[3], E. Todd Bradley[5], David T. Blewett[3], Mark S. Robinson[6], Mark C. Kochte[3], Mark R. Lankton[3], Scott L. Murchie[3], Kerri L. Donaldson Hanna[2], and Elizabeth A. Jensen[7]. [1]MMT Observatory, Tucson, AZ 85721, fvilas@mmto.org; [2]LPL, U. Arizona, Tucson, AZ 85721; [3]JHU-APL, Laurel, MD 20723; [4]LASP, U. Colo., Boulder, CO 80303; [5]Physics, U. Central Florida, Orlando, FL 32816; [6]SESE, Arizona State U., Tempe, AZ 85251; [7]ACS Consulting, Houston, TX 77001.

Introduction: During the first MESSENGER flyby of Mercury, the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) UltraViolet and Visible Spectrometer (UVVS) will be used briefly to obtain limited reflectance spectra of Mercury's surface. These spectra will cover the wavelength range 116.85 – 320.2 nm. Specific questions about the characteristics of Mercury's surface mineralogy can be addressed by these spectra.

Ultraviolet Effects of Space Weathering: Mercury's location near the Sun renders it a candidate for extensive surface modification of the type observed in lunar soil samples [1,2,3], simulated in laboratory experiments [4], and proposed to affect lunar soils [1]. The lunar soil modifications include thin nanophase iron ($npFe^0$) spheres in amorphous rims and lunar agglutinates caused by micrometeoroid impact, solar wind sputtering, or energetic cosmic and solar rays [5]. In the visible/near-infrared (VNIR), the result of the creation of $npFe^0$ in mafic silicates is to darken the material, decrease the depth of absorption features, and redden the overall spectrum at wavelengths >600 nm [2,3]. In a mature lunar soil, agglutinates constitute 50 – 60% of the soil [6]. The regolith of Mercury could consist largely of agglutinates. Further, the surface material near Mercury's equator could be subject to Ostwald ripening, a condition where $npFe^0$ particles in a glass matrix will coarsen and grow in size at temperatures above 200°C [6].

Spectra of lunar soils also show additional characteristics of weathering at ultraviolet (UV)/blue wavelengths. In non-opaque materials, spectral reflectance at VNIR wavelengths is controlled by volume scattering. At UV wavelengths, surface scattering dominates. The transition between volume and surface scattering occurs within the range 150 – 450 nm and is marked by a drop in reflectance. Spectra of opaque materials are dominated by surface scattering and are spectrally flat over the UV/blue wavelength region. Thus, compared to spectra of non-opaque materials expected on Mercury's surface such as pyroxenes and feldspars, Fe-bearing opaques such as $npFe^0$ are relatively bright at UV wavelengths. The non-opaque materials decrease in brightness as they transition to reflectance dominated by surface scattering.

Laboratory spectra of lunar soils show a bluing at UV/blue wavelengths, and a reddening at wavelengths greater than ~600 nm compared with unweathered, powdered lunar rocks (Fig. 1) [7]. At wavelengths <200 nm, the spectra of lunar soils also show an upturn in brightness. Similar effects are observed in UV spectra of asteroid 4 Vesta, even though Vesta's VNIR spectra show pyroxene absorption features having no lunar-like space weathering characteristics [8]. Thus, the UV/blue spectral region might be a more sensitive indicator of space weathering than the VNIR [8].

Mercury's ground-based reflectance spectra uniformly show strong reddening [cf. 9,10]. The expected 1.0-µm silicate absorption feature is largely absent [9,10]. The UVVS surface spectra could confirm and characterize the presence of space weathering.

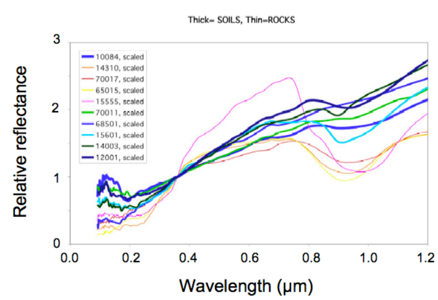

Fig. 1. Laboratory spectra of lunar soils and powdered rocks [7]. Figure from Hendrix and Vilas [11]. Spectra are scaled to 1.0 at 0.35 µm. The more weathered lunar soils are redder in the visible-NIR, but bluer in the UV region, than the less weathered powdered lunar rock samples.

Surface Mineralogy: Almost all materials we expect to find on Mercury's surface have reflectance spectra that show strong UV absorption bands at wavelengths < 200nm [7,12] due to valence conduction band transitions (Figs. 2a,b). At near-UV wavelengths, absorptions due to charge transfer transitions are also observed [cf. 7]. The compositional information that can be derived from these spectral features both augments and elaborates on the information that is derived at VNIR wavelengths. We present three examples here:

The presence and form of iron in Mercury's surface mineralogy are critical to understanding Mercury's composition and surface processing. Observations of the FeO charge transfer transition at 260 nm [13] would provide additional confirmation of the presence and amount of FeO in Mercury's surface mineralogy.

Ilmenite (TiO_2) is a strong candidate material for the opaque that darkens Mercury's surface regolith. In the far-UV, the spectrum of ilmenite is distinctive, showing absorption maxima at 148 and 198 nm, a minimum at 184 nm, and an FeO absorption at 250 nm [7] (Fig. 2a). Spectral evidence of ilmenite in the UV would confirm identifications sought by the Mercury Dual Imaging System.

Ground-based mid-IR emission spectra have identified plagioclase feldspars in Mercury's surface regolith [14,15]. Fe-free feldspars are featureless across the spectral region covered by the MASCS VIRS. Spectra in the UV could confirm the presence of Fe-free feldspar as a major mineralogical component by delineating a characteristic UV spectral shoulder (Fig. 2b) [7].

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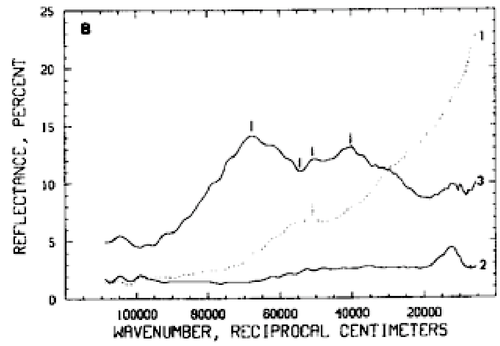

Fig. 2a

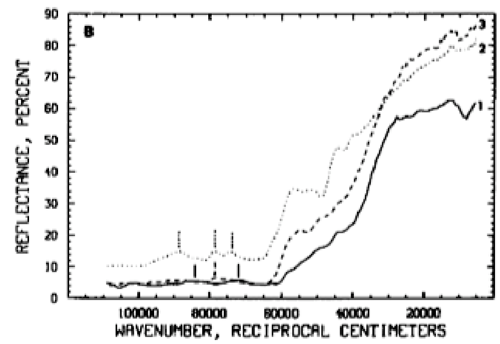

Fig. 2b

Fig. 2. Reflectance spectra of sample candidate materials for Mercury's surface. Spectra are shown by wavenumber (cm^{-1}) in order to emphasize the UV spectral region (a sample conversion is 300 nm = 33333.33 cm^{-1}). Figures from Wagner et al. [7]. Known far-UV wavelength maxima are marked with vertical tick marks [7]. (a) Opaques: 1. iron, 2. magnetite, 3. Ilmenite. (b) Plagioclase feldspars: 1. anorthite (Apollo sample 60025), 2. albite, 3. adularia.