MERCURY COLOR AND ALBEDO: NEW INSIGHTS FROM MESSENGER.

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Introduction: Color and albedo variations across the surface of an airless silicate body are predominantly controlled by two factors, composition and state of regolith maturity. Therefore, identifying and characterizing color and albedo units provides a basis for understanding crust and mantle evolution. Mariner 10 multispectral (355, 475, 585 nm) observations of Mercury revealed a planet with albedo contrasts similar to those observed in the lunar highlands (with no maria) and color variegations not wholly similar to those of any other body [**1,2,3,4,5**]. Even with the limited spectral range of the Mariner 10 filters, these data showed color units resulting from both lunar-like maturation processes as well as variations in composition (**Fig. 1**) [**3,4,5**]. The color and albedo units cataloged from the Mariner 10 data include: 1) high-albedo relatively blue ejecta, 2) a dark halo around Basho crater, 3) low-albedo blue material associated with some basins (**Fig. 1**), and 4) high-albedo relatively red material found in the floors of a few craters [**1,2,3,4,5**]. However, definitive interpretation of the color units thought to be compositional in nature (units 3 and 4) has eluded the science community due to the limited spectral range of the Mariner 10 images [**1,2,3,4,5**]. Earth-based spectral measurements across a wide range of the electromagnetic spectrum indicate that Mercury's crust is low in FeO and opaque minerals (<6 wt% total), and possibly enriched in Ca and Al with the dominant minerals being anorthite and low-Fe, high-Ca pyroxenes [*cf.* **6,7**]. However interpretation of these data is hampered by questions regarding the state of maturity of Mercury's surface. Relative to the Moon, differences in key environmental parameters (*e.g.* gravity, numbers and impact velocities of micrometeorite impacts, radiation environment) should result in a regolith on Mercury that has more reduced iron and a higher percentage of impact glass (agglutinates), produced in an accelerated fashion [**8,9**]. Maturation products tend to suppress reflectance features diagnostic of key minerals thus the hyper-mature state of Mercury's regolith could mask its composition in the spectral measurements obtained from Earth.

Many remaining questions regarding the nature of Mercury's surface [**10,11**] can be informed by high spectral/spatial resolution visible to near-infrared reflectance measurements possible only from a spacecraft. Examples include: What is the temporal, areal, and volumetric significance of volcanic materials? Do impact basins reveal layering in the crust or expose mantle materials? Does the average mature surface consist of regolith with greater than 90% glass?

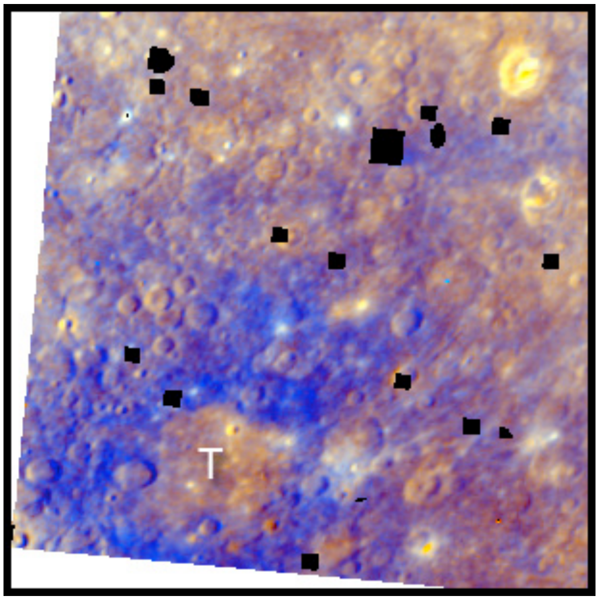

Fig. 1. *Enhanced color composite of the Tolstoj basin region. The color scheme and spectral parameters from [**3,4**]. Increasing redness indicates decreasing abundance of opaque minerals; green is an iron/maturity parameter; and blue shows the relative color (ultraviolet/orange ratio). "*T*" denotes center of the Tolstoj smooth plains. Note that a distinct color parameter boundary coincides with the underlying Goya formation (here seen as blue). Black indicates no data, width of smooth plains is ~50 km.*

MESSENGER at Mercury: The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft was specifically designed to address these and other outstanding questions with the Mercury Dual Imaging System (MDIS) and the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) in concert with the full suite of instruments described in [**11,12,13**]. MESSENGER's first encounter with Mercury will occur on 14 January 2008, allowing detailed multispectral MDIS observations of close to one hemisphere of Mercury with an equatorial profile of MASCS spectra [**14,15**]. These instruments will provide the first spectral data able to resolve small fresh ejecta deposits across a variety of geologic units. Fresh ejecta still retains the spectral signature of underlying crystalline material unaffected by space weathering processes. As mentioned above, space weathering is an insidious process that works to suppress spectral reflectance absorption features thus making their identification and interpretation problematic. By resolving these small (>5km) patches of fresh material the most definitive mineralogic interpretations will be possible locally, also enabling more confident interpretations of the broader scale mature regions.

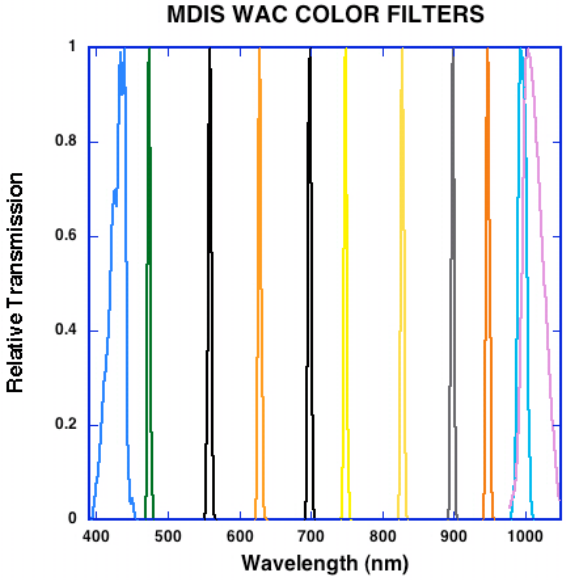

Fig 2. *Relative spectral sensitivity of the WAC filters.*

The current paucity of high-resolution spectral measurements has led to numerous models of Mercury's bulk composition, the common theme being a highly reduced body with a large iron metal core and a Ca- and Al-enriched silicate mantle and crust [**16**]. The mineralogical and compositional interpretations of the upcoming MASCS data provide an opportunity to make accurate estimates of the bulk major element chemistry of the silicate portion of Mercury (mantle and crust). Assuming that Mercury indeed has volcanic material on its surface then MESSENGER will sample material that derived from the mantle, potentially from different depths and times. Terrestrial petrologic studies have shown that the composition and environment of parent material can be determined from the products of partial melting extruded to the surface [**17,18**]. Such information is required to sharpen our view of Mercury's formation and evolution as a whole.

MDIS: MDIS consists of two camera heads, a multispectral Wide Angle Camera (WAC) and a panchromatic Narrow Angle Camera (NAC) [**12**]. The WAC and NAC field-of-views subtend 10.5° × 10.5° and 1.5° × 1.5°, respectively. The WAC has 11 narrow-band filters (**Fig. 2**) selected to characterize reflectance features due to opaque mineralogy, pyroclastic glasses, and the 1-µm mafic absorption (pyroxenes and olivine). Both the WAC and NAC are radiometrically characterized and will provide key datasets to discriminate the dominant mineral species on the surface. The focus of the flyby observations will be to cover most of the visible hemisphere in all eleven filters [**14**] at 2-km resolution, thus providing spectral coverage for discriminating among units of different composition and maturity. The dedicated photometric observations will provide structural insight that correlates with regolith maturity and processing.

MASCS-VIRS: The MASCS consists of a Cassegrain telescope that feeds the Visible and Infrared Spectrograph (VIRS) and the Ultraviolet and Visible Spectrometer (UVVS) [**13,15**]. VIRS is a point spectrometer with a 0.023° field of view, sensitive over the wavelength range 320-1450 nm at 5 nm resolution. The UVVS is a scanning grating monochromator with three spectral channels: FUV (115-190 nm), MUV (160-320 nm), and VIS (250-600 nm). The UVVS subtends 0.05° × 0.04° for surface observations. Both spectrometers within the MASCS instrument will be observing the surface during the flyby, thus providing a very high-spectral-resolution complement to the hemispheric MDIS multispectral mapping [**15,19,20**].

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