MAPPING OF OPTICAL MATURITY ON MERCURY. David T. Blewett[1], Brett W. Denevi[1], Carolyn M. Ernst[1], Nancy L. Chabot[1], and Catherine D. Neish[2]. [1]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, 20723, USA; [2]Department of Physics and Space Sciences, Florida Institute of Technology, Melbourne, FL, 32901 USA. (david.blewett@jhuapl.edu).

Space Weathering on the Moon: In response to space weathering (bombardment by micrometeoroids and solar wind ions), the Moon's regolith undergoes physical and chemical changes that strongly alter the manner in which it reflects radiation in the ultraviolet to near-infrared portion of the electromagnetic spectrum [see review by 1]. This optical alteration involves both darkening (decrease in overall reflectance) and color changes in the form of a stronger decrease in reflectance at shorter wavelengths than at longer wavelengths that produces a "reddened" continuum slope. Space weathering is also associated with a weakening of mineralogical absorption bands. The chief cause of the optical effects associated with lunar space weathering is the accumulation of microphase and nanophase blebs and coatings of metallic iron, produced when micrometeoroid and ion impacts cause melting and vaporization of regolith particles, with associated reduction of ferrous iron in silicates to the native state [e.g., 1-3]. Lucey and colleagues [4] defined a parameter derived from multispectral imaging at 750 and 950 nm that is a measure of lunar optical maturity (OMAT). The OMAT parameter is, to first order, decoupled from the composition of the surface (maria versus highlands) and simply reflects the extent to which space weathering has affected a surface.

Space Weathering on Mercury: Mercury differs from the Moon in several key aspects related to space weathering [e.g., 5-7], including the low iron content of the surface (<~2 wt.% FeO on Mercury [8] versus >~5-6 wt.% FeO in the lunar highlands and >~15 wt.% FeO in the maria). Mercury has an internally generated magnetic field, which may partly shield the surface from solar wind ions, although processes in Mercury's magnetosphere lead to an enhanced flux of very energetic ions bombarding the surface at certain locations and times [9]. The flux and energy of micrometeoroids striking Mercury are thought to be much higher than for those hitting the Moon [5].

Mercury's general optical maturation trend appears to be qualitatively similar to that of the Moon: mature surfaces are darker and redder than freshly exposed crater ejecta [10, 11]. Thus the observed trend is consistent with the accumulation of micro- and nanophase iron [12, 13], supplied by either endogenous Mercury material, delivery by meteoroid impactors [6], or both. Blewett and colleagues [11] examined a single multispectral scene of one hemisphere of Mercury (5 km/pixel), obtained during the *MESSENGER* spacecraft's first flyby of the planet, and employed the Lucey OMAT algorithm [4] to produce a maturity image of Mercury. That maturity image suppresses variations associated with major regional albedo and compositional differences (low-reflectance material vs. intermediate terrain vs. high-reflectance plains [10, 11, 14]), leaving variations related to the presence of crater rays and other immature surfaces.

Mercury Optical Maturity – A Second Look: A global multispectral mosaic in eight colors (660 m/pixel) has been assembled from images obtained with the *MESSENGER* Mercury Dual Imaging System's Wide Angle Camera (MDIS-WAC) [15]. The global coverage and higher spatial resolution of this data product allow a more detailed look at the planet's spectral character than did the single frame employed previously [11]. Note that eight-color orbital mapping does not include the 950-nm filter, so that it is not possible to use the earlier algorithm [11] with the global orbital data.

As a first step in our reexamination of Mercury optical maturity, we produced an optical maturity image motivated by the observation that the major spectral differences among Mercury's surface units are in (a) overall albedo and (b) spectral slope [10, 11, 14]. For example, the low-reflectance material (LRM) is dark and has a relatively shallow (flatter or "bluer") spectrum, whereas the high-reflectance red plains (HRP) are characterized by higher albedo and a steeper ("redder") spectral slope. Intermediate terrain has reflectance and spectral slope that fall between those of the HRP and LRM. Within each terrain type, fresher materials have higher reflectance and flatter slopes. We find that a useful maturity index can be made by normalizing the reflectance of an image pixel by the spectral slope [16]. The parameter is computed as follows: From images in the eight MDIS spectral bands (430 to 997 nm), we obtain a wavelength-averaged reflectance image. At each pixel we estimate the spectral slope by fitting a line to the spectrum at that pixel, and we construct a corresponding image of spectral slope. To produce the optical maturity index for Mercury, the average reflectance image is divided by the spectral slope image. As can be seen in Fig. 1, this procedure is largely successful and yields an image in which albedo differences related to the major terrain types are minimized, leaving an image dominated by maturity variations. For example, the HRP that fill the Caloris basin and the LRM surrounding Tolstoj do not stand out in the maturity image. Ray systems appear in the maturity image against a mostly neutral background.

One focus of our work is a search for compositional rays [17]. The rays surrounding an unnamed crater between Lermontov and Handel show little contrast with the surroundings in the maturity image, suggesting that they may have a compositional component.

As the radiometric calibration of the data [18] and the photometric normalization [19] continue to be refined, detailed assessment of space-weathering trends within the various color-compositional surface units can be carried out, leading to improved methods for measuring optical maturity on Mercury.

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Figure 1. Global mosaics of Mercury (65°N to 65°S, with longitude 0° at the center), in equirectangular projection [16]. *Top*: Wavelength-averaged reflectance image made from the eight MDIS color base map filter mosaics. Dashed circle = Caloris basin. "T" = Tolstoj. "D" = Debussy. "H" = Hokusai. *Bottom*: Optical maturity image. Fresher materials appear bright in this image, regardless of composition. Compared with the average reflectance image, regional albedo differences have largely been suppressed (e.g., Caloris and Tolstoj). Calibration and photometric artifacts are visible in some areas of the optical maturity image.