EPSC Abstracts
Vol. 13, EPSC-DPS2019-1088-1, 2019
EPSC-DPS Joint Meeting 2019


EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

# Examining Localized Occurrences of Low-Reflectance Material on Mercury

**R. Klima** (1), B. Denevi (1), and C. Ernst (1). (1) Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA. (Rachel.Klima@jhuapl.edu / Fax: +1-443-778-8939

## Abstract

Low reflectance material (LRM) is found across the surface of Mercury, and has been interpreted as being darkened by carbon. In global mapping efforts, LRM is associated with a broad, shallow ~600 nm absorption band, that correlates with carbon content in the regions that have been measured directly with the neutron spectrometer. However, because LRM is often associated with hollows, it is possible that the spectral signature of LRM that is observed on a global scale actually consists of a mixture of a dark, flat spectrum, characteristic of carbon, and an absorption in the hollows spectrum, perhaps due to sulfides or another phase. We examine high resolution color images of prominent LRM deposits, with and without prominent hollows within them, to investigate the origin(s) of the 600-nm feature in MESSENGER color MDIS data.

## 1. Introduction

Distinctive LRM was first observed on Mercury in Mariner 10 flyby images [1]. Visible to near-infrared reflectance spectra of LRM are flatter than the average reflectance spectrum of Mercury, which is strongly red sloped (increasing in reflectance with wavelength). From Mariner 10 and early MErcury, Surface, Space, ENvironment, GEochemistry, and Ranging (MESSENGER) flyby observations, it was suggested that a higher content of ilmenite, ulvöspinel, carbon, or iron metal could cause both the characteristic dark, flat spectrum of LRM and the globally low reflectance of Mercury [1,2]. Once MESSENGER entered orbit, low Fe and Ti abundances measured by the X-Ray and Gamma-Ray Spectrometers ruled out ilmenite and ulvöspinel as important surface constituents [3,4] and implied that LRM was darkened by a different phase, such as carbon or small amounts of micro- or nanophase iron or iron sulfide dispersed in a silicate matrix. Low-altitude thermal neutron measurements of three LRM-rich regions confirmed an enhancement of 1–3 wt% carbon over the global abundance, supporting the hypothesis that the darkening agent in LRM is carbon [5].

## 2. Mapping LRM On Mercury

LRM is distributed across Mercury, typically having been excavated from depth by craters and basins. In contrast to the brighter high reflectance plains (HRP) and smooth plains deposits, which exhibit morphological evidence of volcanism [e.g., 6-8], LRM is not associated with flow features or other evidence of a volcanic origin. Older LRM boundaries are generally diffuse, and grade into low-reflectance blue plains (LBP). Because of the common lack of sharp geologic boundaries, LRM has been defined primarily based on albedo and spectral shape, isolated through principal components (PC) analyses of MDIS color images [9]. LRM is the darkest material on Mercury, with an albedo of 4–5% at 560 nm, and it exhibits a spectral slope that is substantially less red (increases less in brightness with increasing wavelength) than the rest of Mercury.

Because PC analyses are calculated using the spectral range over a given data set, a PC2 constraint cannot be directly translated to individual targeted color images, except in the rare case of images that contain the full range of Mercury's spectral diversity. The broad, shallow band centered near 600 nm that is observed in LRM (and also often in hollows material) can be isolated directly by dividing the planet as a whole by a reference spectrum and then calculating a band depth ratio. Murchie et al. [10] found that the most successful ratio for mapping the LRM was calculated by first dividing the full mosaic by a reference spectrum of the northern volcanic plains, and then calculating the ratio as:

$$\sim 600\ nm\ band\ depth = 1 - \left[ \frac{(R560 + R630 + R750 + R830)/4}{(R900 + R480)/2} \right]$$

where R is photometrically corrected reflectance in each of the given filters. Figure 1 presents a comparison between a simple 3 band color image, a 3-band enhanced color image using PC1 and PC2, and an enhanced color image using 600 nm band depth, albedo at 560 nm, and 430/1000 nm slope.

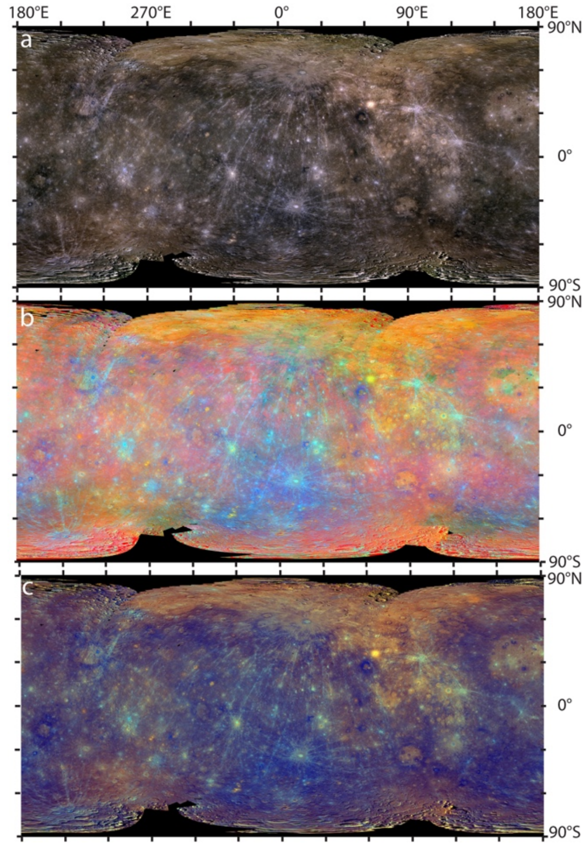


**Fig. 1. (a)** False color global map of Mercury with R=1000 nm, G=750 nm and B=430 nm. LRM shows up as dark bluish-black material, and grades into the slightly brighter LBP. **(b)** Enhanced color composite of Mercury with R= ~600-nm broad band depth (inverted, stretched from 0-6% band depth), G=560 nm albedo (stretched from 0-10% albedo), B=430/1000 nm slope (stretched from 0.396-0.593). **(c)** Enhanced color composite of Mercury with R=PC1, G=PC2, B=430/1000 nm slope. (a&b adapted from Klima et al., 2018).

# 3. Global Results

Unlike the PCA-derived enhanced color composite, which separates all spectral diversity on Mercury and highlights the full diversity of the planet, the enhanced color composite shown in Fig1b focuses on examining properties of the LRM and hollows material. Both types of material exhibit a shallower spectral slope than average Mercury, and a curvature that is captured in the 600-nm band depth. The obvious difference is in the albedo, with hollows being extremely bright and LRM extremely dark, resulting in hollows appearing cyan, and LRM appearing blue. An example of Basho crater is shown in Figure 2. The similarity in the band depths for hollows and LRM does not necessarily imply that the 600-nm curvature has to be due to hollows, however. As can be seen in Fig. 1, some crater ejecta is clearly cyan, consistent with hollows, but the ejecta rays have not so far been suggested to contain hollows. Since the 600-nm band highlights differences in curvature, it could, in bright material, just be capturing the lack of space weathering relative to average Mercury.

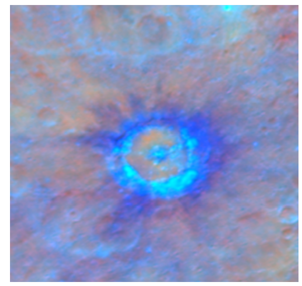

**Fig. 2.** Enhanced color composite of Basho crater with R= ~600-nm broad band depth (inverted, stretched from 0-6% band depth), G=560 nm albedo (stretched from 0-10% albedo), B=430/1000 nm slope (stretched from 0.396-0.593). Hollows within the crater walls and peak appear as bright cyan, and the LRM ejecta appears as deep blue.

# 4. Local Studies

Clearly, many factors are intertwined with the current parameterization of the 600-nm feature. To begin to tease apart and test the hypothesis that the 600-nm feature in LRM is directly caused by carbon, we will present the results of an examination of several LRM-rich craters with clear ejecta rays using high resolution color images to compare their spectral properties.

# Acknowledgements

We are grateful to the NASA PMDAP program for supporting this work (#NNX14AM93G).

# References

[1] Hapke, B. et al. (1975) *JGR* 80, 2431. [2] Robinson, M.S. et al. (2008) *Science* 321, 66. [3] Nittler, L.R. et al., (2011) *Science* 333, 1847. [4] Evans, R.G. et al. (2012) JGR 117, E00L07. [5] Peplowski, P.N. et al. (2016) *Nat. Geosci.* 9, 273-278. [6] Head, J.W. et al., (2011) *Science* 333, 1853–1856. [7] Whitten, J. L., et al. (2014) *Icarus* 241, 97-113. [8] Denevi, B.W. et al., (2013) *JGR Planets* 118, 891–907. [9] Klima et al. (2018) *GRL*. [10] Murchie, S.L. et al. (2015) *Icarus* 254, 287.