Global Distribution of Carbon-Rich Material on Mercury's Surface

RACHEL L. KLIMA*, PATRICK N. PEPLOWSKI, BRETT W. DENEVI, SCOTT L. MURCHIE, CAROLYN M. ERNST,

Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd. Laurel, MD 20723, USA.
*correspondence:Rachel.Klima@jhuapl.edu

Distinctive low-reflectance material (LRM) was first observed on Mercury in Mariner 10 flyby images [1]. Visible to NIR reflectance spectra of LRM exhibit a flatter and darker slope than the average reflectance for Mercury, which is dark but strongly red sloped. In some cases, LRM spectra also exhibit a curvature suggestive of a weak, broad absorption band near 600 nm [2,3]. From Mariner 10 and early MESSENGER flyby observations, it was suggested that ilmenite, ulvöspinel, carbon, or Fe metal could cause the characteristic dark, flat spectrum of LRM and the global darkening of Mercury [1,2]. However, 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 constituents and implied a different darkening phase, such as carbon or small amounts of micro- or nanophase opaque minerals dispersed in a silicate matrix [3-5]. Targeted, low-altitude thermal neutron measurements for three LRM-rich regions suggested an enhancement of 1-3 wt% carbon over the global abundance [6], supporting the hypothesis that the darkening agent in LRM is carbon [3].

Across the surface of Mercury, LRM shows clear evidence of having been excavated from depth. In cases where it is not clearly associated with specific craters, it occurs in patchy spots within broad regions where the ejecta from numerous small craters overlap. The sporadic excavation of LRM argues for a discontinuous distribution within the crust, as previously suggested [6], or at least by different LRM burial depths. The three LRM regions measured by neutron spectrometry [6] are spatially and spectrally representative of the diversity of LRM observed globally. A ~600-nm absorption, potentially associated with graphite, is present in the fresher exposures of LRM. This evidence supports the presence of a graphite-rich subsurface, perhaps the remnants of a magma ocean floatation crust [7].

[1] Hapke, B. et al. (1975) *JGR* **80**, 2431. [2] Robinson, M.S. et al. (2008) *Science* **321**, 66. [3] Murchie, S.L. et al. (2015) *Icarus* **254**, 287. [4] Nittler, L.R. et al., (2011) *Science* **333**, 1847. [5] Evans, R.G. et al. (2012) *JGR* **117**, E00L07. [6] Peplowski, P.N. et al. (2016) *Nature Geosci*., **9**, 273-278. [7] Vander Kaaden, K.E. and McCubbin, F.M. (2015) *JGR Planets* **120**, 195.