MERCURY PYROCLASTICS: COLOR, MORPHOLOGY, AND VOLATILE CONTENT. David T. Blewett[1], Laura Kerber[2], James W. Head[2], Brett W. Denevi[3], Mark S. Robinson[3], Scott L. Murchie[1], Jeffrey J. Gillis-Davis[4], and Sean C. Solomon[5]. [1]Johns Hopkins Univ. Applied Physics Lab., 11100 Johns Hopkins Road, Laurel, MD 20723, USA (david.blewett@jhuapl.edu). [2]Dept. of Geological Sciences, Brown Univ., Providence, RI 02912, USA. [3]School of Earth and Space Exploration, Arizona State Univ., Tempe, AZ 85287, USA. [4]Hawaii Inst. of Geophysics and Planetology, Univ. of Hawaii, Honolulu, HI 96822, USA. [5]Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington, DC 20015.

Introduction: Examination of the products of explosive volcanism can provide information on the composition and volatile inventory of a planet's crust and mantle. Pyroclastic deposits have been recognized in images obtained during MESSENGER's first two flybys of Mercury. In this contribution we use MESSENGER data to revisit a suspected pyroclastic deposit identified in Mariner 10 images, review the morphological and spectral characteristics of newly discovered pyroclastic deposits, and explore the magma volatile contents implied by the deposits.

Mariner 10: Mariner 10 two-color images have been processed to produce spectral parameter maps related to optical maturity and the abundance of opaque minerals [1, 2]. Dark, relatively blue material material with high opaque abundance exhibiting diffuse boundaries and possibly draping the surrounding terrain was noted near the large crater Homer [1, 3]. These characteristics are consistent with pyroclastic emplacement, and the location along a straight segment of the Homer rim was interpreted to be suggestive of a fissure eruption. Higher-resolution and multispectral MESSENGER images of this area (Fig. 1) show that the dark, bluish material is more likely to be ejecta from the ~100-km-diameter crater west of the Homer rim segment. Low-reflectance material (LRM) is now recognized as a major surficial unit on Mercury [4-7], found both at the surface and in crater and basin deposits where it has been excavated from depth.

MESSENGER First Mercury Flyby: During the first flyby of Mercury, the Mercury Dual Imaging System (MDIS) collected images of the planet with the multispectral Wide Angle Camera (WAC) and the monochrome Narrow Angle Camera (NAC). The portion of the planet imaged during the departing leg of the flyby includes the Caloris basin. A number of "red spots" were identified in multispectral parameter images [4, 7, 8]. The red spots (Fig. 2) have high reflectance and a spectral slope that is steeper ("redder") than the global average, and many within and near Caloris have morphological characteristics (e.g., diffuse-bordered bright halo surrounding an irregular depression) consistent with pyroclastic deposits [8-10]; some other red spots away from Caloris are likely to be small deposits of smooth plains material (e.g., the interior of the crater Moody [7]).

MESSENGER's Second Mercury Flyby: The area imaged during the second MESSENGER flyby also displays features likely to be pyroclastic deposits. Several red spots correspond to craters whose floors contain high-reflectance, relatively red material located around irregularly shaped depressions. Examples include the craters Lermontov, Mistral, and a crater near Antoniadi Dorsum at 27.2° N, 330.5° E (Fig. 3).

Color and Composition: Many regional and local pyroclastic deposits on the Moon have low reflectance, are often referred to as "dark mantle deposits (DMD)" [e.g., 11], and have compositions (i.e., Fe and Ti) similar to mare soils. From this analogy, it was thought that pyroclastic deposits on Mercury might be similarly dark and mafic in composition [1-3]. However, data from MESSENGER now demonstrate that the features having a morphology clearly consistent with a pyroclastic origin discovered on Mercury to date have high reflectance (compared with their surroundings) and spectra with redder than average color and low opaque abundance. Reflectance spectra of these deposits lack a mafic mineral absorption near 1 μm [4, 7, 8], suggesting a low abundance of ferrous iron (less than a few weight %) in the silicate portion.

Volatile Content: Consideration of eruption physics permits parameters such as the speed of ejection of pyroclasts and the abundance of magmatic gases driving the eruption to be estimated [e.g., 10, 12]. The average distance from the vent to the edge of the deposit shown in the inset of Fig. 2 is 24 km. The area of the deposit is larger than many lunar pyroclastic deposits [11], and the Fig. 2 deposit would be even larger if scaled to the Moon's surface gravity. Calculations of the volatile abundance to launch reasonably-sized pyroclasts to a distance of 24 km indicate that ~2400 ppm of CO would be required on the Moon, and ~5500 ppm CO for Mercury [10]. For other volatiles, 3600 to 13,000 ppm would be needed to produce the observed deposit [10]. These abundances are comparable to or larger than the volatile contents of terrestrial oceanic basalts, and are surprising because most models of Mercury's formation predict a depletion in volatiles [e.g., see review in 13]. Study of other suspected pyroclastic deposits will provide new knowledge of the importance of volcanism in the planet's geological history and will inform a broad range of topics ranging from planetary formation to the history of outgassing from the planet's interior.

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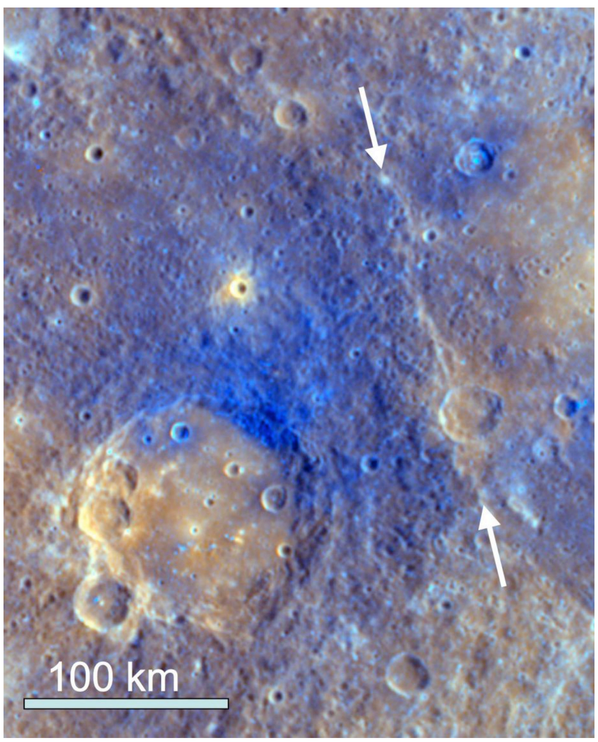

Figure 1↑. NAC-WAC color composite image of the western rim of Homer basin, centered near 2° S, 319° E. A segment of the basin rim extends between the arrows. R = inverse PC2, G = PC1, B = color ratio (430 nm/560 nm, brighter = less red). See [4] for explanation of principal component (PC) images.

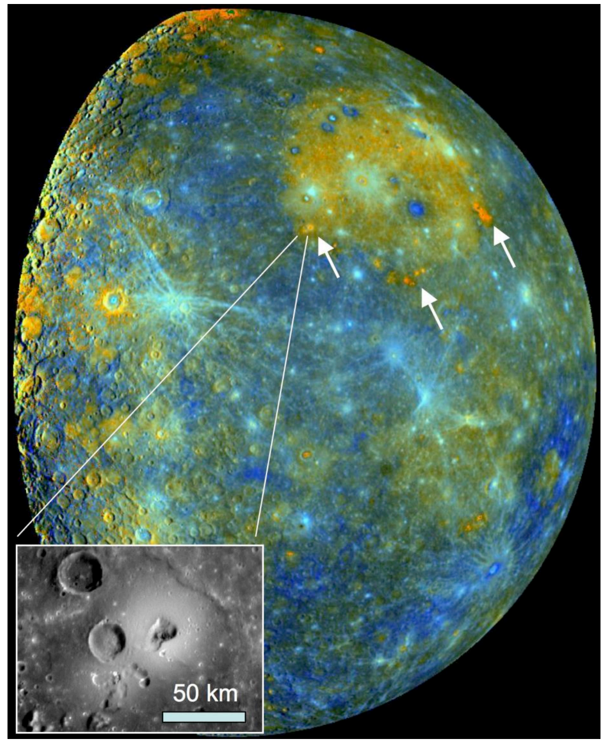

Figure 2↑. WAC spectral parameter composite image in orthographic projection centered at 0°, 133° E. R = inverse opaque parameter [1, 2, 7] (brighter = lower opaques), G = 560-nm reflectance, B = color ratio (430 nm/750 nm, brighter = less red). Arrows indicate red spots interpreted to be pyroclastic deposits. Inset: NAC image of kidney-shaped depression surrounded by high-reflectance shield-like construct.

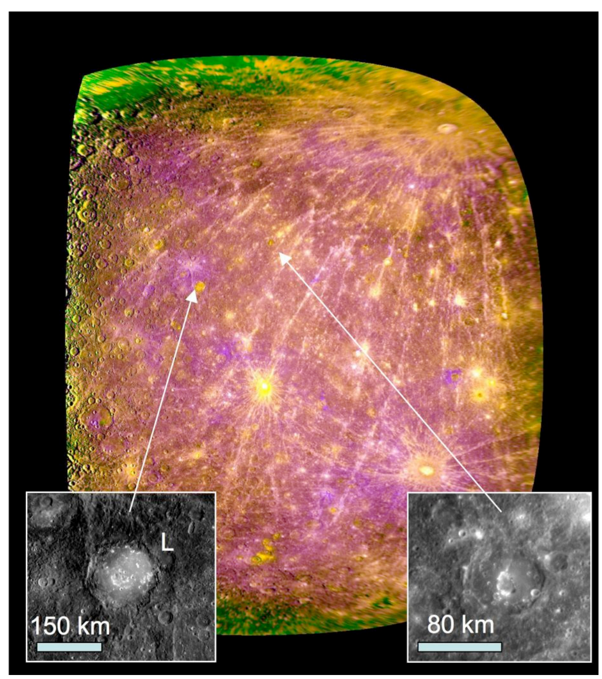

Figure 3→. WAC spectral parameter composite image in simple cylindrical projection with center longitude 0°. Color representation same as Fig. 2 (different stretch). Left inset: NAC image of Lermontov (L). Right inset: crater near 27.2° N, 330.5° E.