IMAGING OF MERCURY'S POLAR DEPOSITS DURING MESSENGER'S LOW-ALTITUDE CAMPAIGN. Nancy L. Chabot[1], Carolyn M. Ernst[1], Hari Nair[1], Ariel N. Deutsch[2], James W. Head[2], and Sean C. Solomon[3,4], [1]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA (Nancy.Chabot@jhuapl.edu). [2]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI 02912, USA. [3]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, USA. [4]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015, USA.

Introduction: Earth-based radar observations and multiple datasets from the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission provide evidence that Mercury's polar regions host deposits dominantly of water ice [e.g., 1, 2]. However, the majority of the deposits are located in regions that are too warm to support water ice at the surface [3], and low-reflectance surfaces observed in these regions [4, 5] have been interpreted to be lag deposits of organic-rich, volatile material. The MESSENGER spacecraft impacted Mercury on 30 April 2015, but during the final year of its orbital operations the spacecraft acquired data at lower periapsis altitudes than ever before, enabling high-spatial-resolution measurements over some areas. Here we present the results from MESSENGER's low-altitude campaign to image Mercury's polar deposits.

Low-Altitude Polar Deposits Campaign: While at low spacecraft altitudes, defined here as <250 km, the Mercury Dual Imaging System (MDIS) acquired 718 images that were targeted to resolve the surfaces of Mercury's polar deposits. Previous work demonstrated that the permanently shadowed surfaces of Mercury's polar deposits can be resolved with MDIS's broadband filter on the wide-angle camera (WAC) and documented the associated challenges with an imaging campaign that involves highly saturated images [5]. Inspection of the 718 images revealed the shadowed surfaces within 35 distinct craters; the footprints for the images that best reveal the polar deposit surfaces are shown in ***Fig. 1***, along with radar-bright [1] and permanently shadowed [6] regions. The low-altitude images identified in ***Fig. 1*** have pixel scales that range from 24 to 100 m.

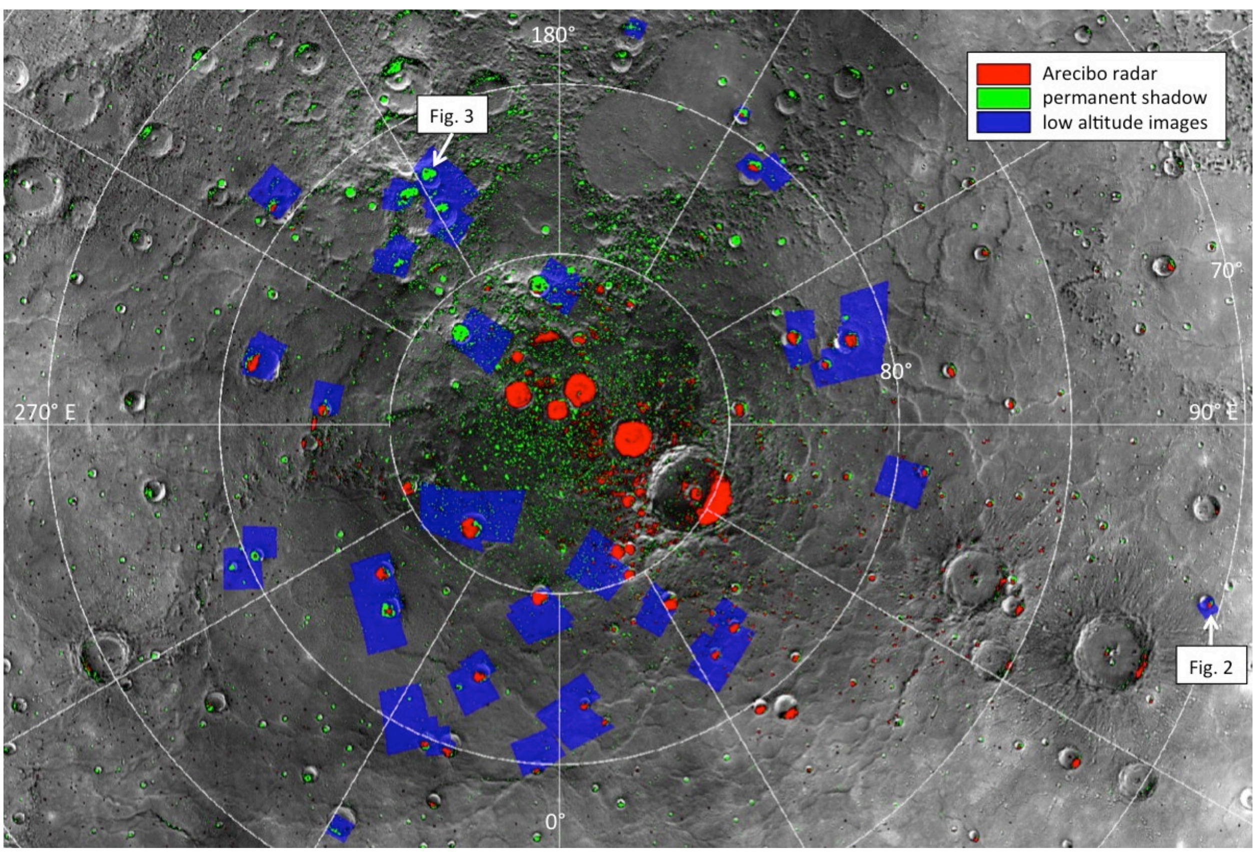

Figure 1. Coverage from MESSENGER's low-altitude campaign to image Mercury's polar deposits. Low-altitude image footprints are shown in blue. Regions with high radar reflectivity in Earth-based images from Arecibo Observatory [1] are displayed in red, and regions of permanent shadow [6] are shown in green.

Results: All of the 35 craters imaged during MESSENGER's low-altitude polar deposits campaign contain low-reflectance surfaces that collocate with regions of permanent shadow. The low-reflectance deposit at 70°N (***Fig. 2***) is at the lowest latitude such deposits have been imaged. The low-reflectance surfaces have sharp boundaries, as noted by an earlier examination of a subset of these images [7]. That the boundaries are sharp even when imaged at resolutions of tens of meters supports the hypothesis that the low-reflectance deposits are geologically young relative to the timescale for lateral mixing by impacts.

Whereas all of the 35 craters contain low-reflectance deposits, some are not identified as radar-bright regions, such as the example in ***Fig. 3***. Given the well-defined, low-reflectance surface in the image and its similarity to images of radar-bright regions, it is likely that the lack of a radar-bright feature associated with this crater is the result of limitations with the coverage of the radar data rather than an absence of water ice in the crater.

The fact that every permanently shadowed crater imaged during MESSENGER's low-altitude imaging campaign hosts low-reflectance deposits supports the notion that all of Mercury's available cold traps are occupied by volatiles and water ice. This inference, like the observation of the sharp boundaries, points either to delivery of volatiles to Mercury in the geologically recent past or to an ongoing process. Modeling of the delivery and retention of water for the Moon by a comet impact showed that such an impact would capture water molecules in cold traps more or less equally in the two polar regions [8]. Thus, the low-altitude imaging evidence suggesting that Mercury's north polar cold traps are all occupied, combined with the extensive radar-bright deposits in Mercury's south polar permanently shadowed regions [1, 9], are consistent with a large, recent impact event as the source of Mercury's water ice, perhaps such as the one that formed Hokusai crater [10].

References: [1] Harmon J.K. et al. (2011) *Icarus, 211*, 37–50. [2] Lawrence D.J. et al. (2013) *Science, 339*, 292–296. [3] Paige D.A. et al. (2013) *Science, 339*, 300–303. [4] Neumann G.A. et al. (2013) Science, *339*, 296–300. [5] Chabot N.L. et al. (2014) *Geology, 42*, 1051–1054. [6] Deutsch A.N. et al. (2016) *LPS, 47,* this mtg. [7] Chabot N.L. et al. (2015) *LPS, 46,* 1274. [8] Stewart B.D. et al. (2011) *Icarus, 215*, 1–16. [9] Chabot N.L. et al. (2012) *GRL, 39*, L09204, doi:10.1029/2012gl051526. [10] Ernst C.M. et al. (2016) *LPS, 47*, this mtg.

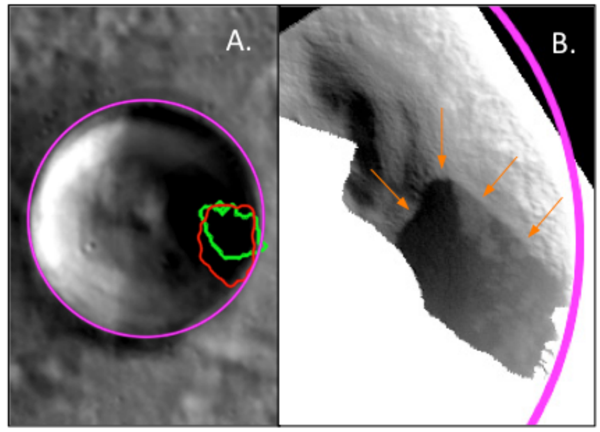

Figure 2. A. Crater at 70.4°N, 74.6°E (18-km diameter, outlined in pink); radar-bright (red) and permanently shadowed (green) regions are outlined. **B.** WAC broadband image EW1059620770 reveals a low-reflectance deposit with sharp boundaries (orange arrows).

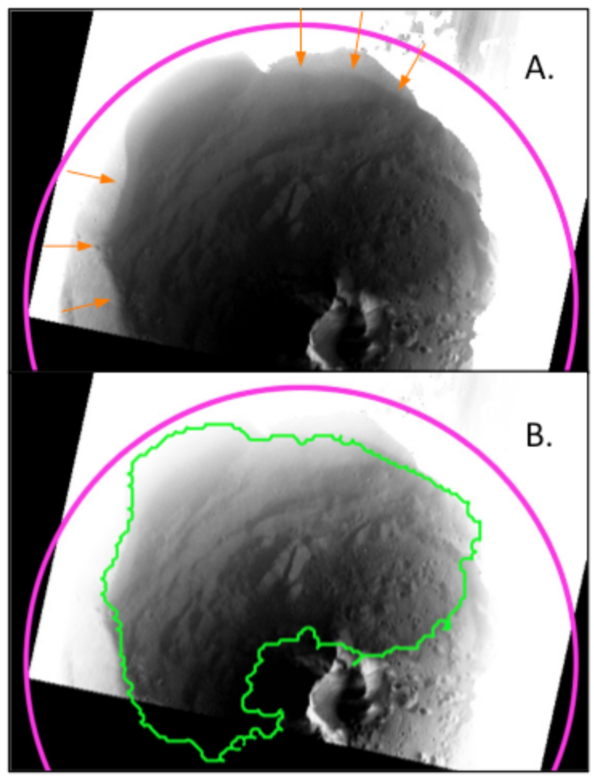

Figure 3. WAC broadband image EW1053138179 of 28-kilometer-diameter crater at 81.8°N, 207.8°E (rim in pink). **A.** Stretched to reveal sharp boundaries of the low-reflectance deposit (orange arrows). **B.** Stretched to reveal features within the deposit; the permanently shadowed region is outlined in green.