RESOLVING THE SURFACES OF MERCURY'S LOW-REFLECTANCE POLAR DEPOSITS WITH IMAGES FROM MESSENGER'S LOW-ALTITUDE CAMPAIGN. Nancy L. Chabot[1], Carolyn M. Ernst[1], Erwan Mazarico[2], Gregory A. Neumann[2], Brett W. Denevi[1], Hari Nair[1], David T. Blewett[1], Scott L. Murchie[1], James W. Head[3], and Sean C. Solomon[4], [1]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA (Nancy.Chabot@jhuapl.edu). [2]NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA. [3]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI 02912, USA. [4]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, USA.

Introduction: Multiple datasets provide evidence that water ice is present in permanently shadowed regions near Mercury's poles: Earth-based radar imaged radar-bright deposits [1–4], visible imaging showed regions of permanent shadow [5], thermal models indicated that temperatures could sustain surface and near-surface water ice [6], and neutron spectrometry detected enhanced hydrogen in Mercury's north polar region [7]. Additionally, visible and near-infrared measurements revealed high- and low-reflectance surfaces on the polar deposits [8, 9]. The high-reflectance values are consistent with the presence of surficial water ice, but the low-reflectance surfaces require an alternative explanation.

Both multi-wavelength radar observations [4] and early thermal models [10] indicated that in many locations near Mercury's poles a thin cover of material likely serves to insulate the water ice from maximum diurnal temperatures. However, prior to observations by the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission, regolith was generally proposed as the material that insulated the water ice in these regions. Given that the surface reflectance is about half that of surrounding areas [8], however, and that the low-reflectance deposits occur in locations where water ice is stable only in the near surface, the cover has been interpreted to be a lag deposit of organic-rich volatile material [6]. Recent MESSENGER visible-wavelength images of polar deposits revealed that the low-reflectance material has sharp boundaries, but those images were limited in resolving other surface morphological features [9].

During the last year of its orbital operations, the MESSENGER spacecraft is acquiring data at lower periapsis altitudes than ever before during the mission. The low altitudes enable datasets of progressively higher spatial resolution for many instruments. Here we share the first results from MESSENGER's low-altitude campaign to image within Mercury's permanently shadowed craters. The images provide new details on the surface morphology of Mercury's low-reflectance polar deposits and have implications for the formation and evolution of those deposits.

Method: Surfaces within permanently shadowed regions on Mercury can be resolved with the broadband filter of the wide-angle camera (WAC) of the Mercury Dual Imaging System (MDIS) [9]. Between 23 August and 9 September 2014, MESSENGER acquired WAC broadband images of the permanently shadowed surfaces within the seven craters shown in ***Fig. 1***. The spacecraft altitude at the time of the WAC observations ranged from 67 to 133 km, resulting in images with 24–47 m/pixel resolution, markedly better than the ~100 m/pixel resolution of previous images [9]. The new images were compared with other datasets from Mercury's north polar region, including Arecibo radar images [4], topography [8], radar viewing opportunities [11], permanently shadowed regions [11], Mercury Laser Altimeter (MLA) reflectance [8], and thermal models [6].

Results: All of the seven permanently shadowed craters imaged at high resolution and identified in ***Fig. 1*** show distinct low-reflectance deposits in their interiors. The locations of the low-reflectance deposits in the images are consistent with the locations of permanent shadow, the thermal stability of sub-surface water ice, and low MLA reflectance values. In some locations, such as Fuller crater (***Fig. 1***), Arecibo radar data do not indicate a radar-bright signal in the crater, but examination of radar viewing dates shows that there were limited opportunities to observe the interior of this crater [11]. We conclude that the lack of a radar-bright feature is likely to be the result of limited radar-viewing opportunities rather than an absence of water ice in the crater.

Overall, we find two main results from these new, higher-resolution images:

1) The low-reflectance deposits are not featureless (***Fig. 2***). The deposits have variations in brightness, a result that contrasts with the uniform reflectance inferred from lower-resolution images [9]. Small craters are also visible in the low-reflectance regions.
2) The low-reflectance deposits display sharp boundaries (***Fig. 2***), a conclusion made earlier from lower-resolution images [9] and affirmed by the higher-resolution images.

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; this inference points either to delivery of volatiles to Mercury in the geologically recent past or to an ongoing process that restores the deposits and maintains sharp boundaries. The patchiness of the reflectance properties of the deposits, however, is not clearly consistent with being geologically young if indicative of the exposure of brighter material by small impact craters, though it would provide an important constraint on the timing or rate of formation of the low-reflectance material. Alternatively, the albedo variations within the deposits could be thermally controlled, an interpretation more consistent with the sharp boundaries and being geologically young. Mapping of the brightness variations within the low-reflectance deposits is warranted to gain a better understanding of this issue.

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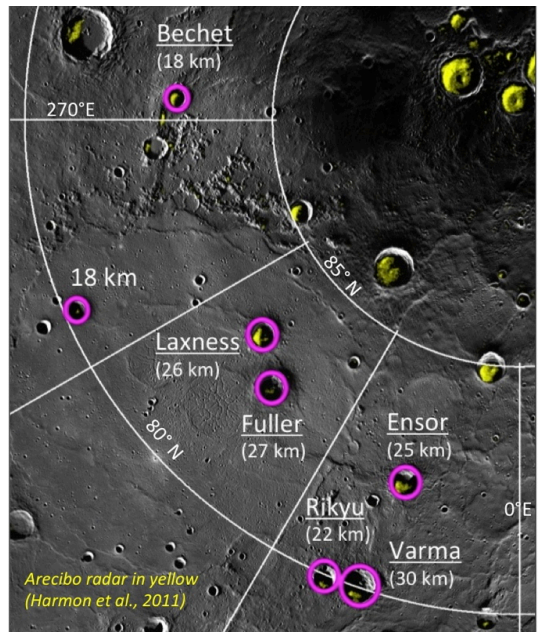

Figure 1. *Locations of seven permanently shadowed crater interiors imaged during MESSENGER's low-altitude campaign in autumn 2014.*

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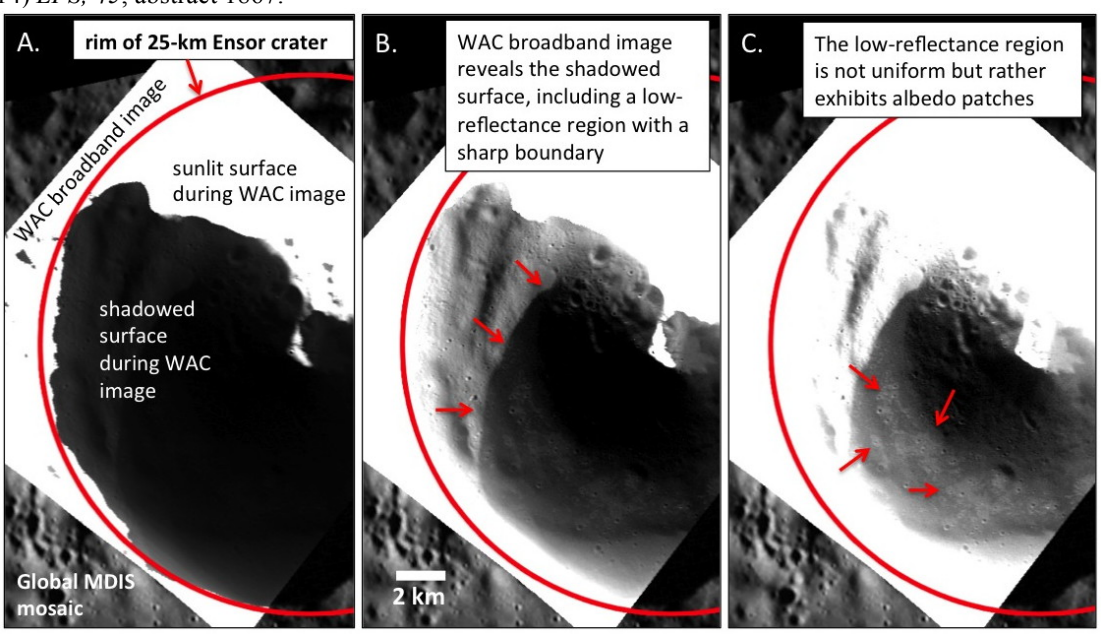

Figure 2. *Ensor crater (82.32°N, 342.47°E), WAC broadband image EW1051458815B, 37 m/pixel.* ***A.*** *Auto-stretched image, showing the sunlit and shadowed areas at the time that the image was acquired.* ***B.*** *Same image with a different stretch to reveal a low-reflectance region with a sharp boundary (arrows); the low-reflectance region extends up the crater wall and is collocated with the area that is permanently shadowed.* ***C.*** *Same image with a third stretch reveals details within the low-reflectance region. The low-reflectance material is patchy rather than uniform in brightness (arrows) and displays small impact craters.*