METER-SCALE SURFACE TEXTURES ON MERCURY: COMPARISON WITH THE MOON.

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Introduction: The surface of the Moon is covered with a layer of regolith, fragmental, highly heterogeneous material. Formation, modification and transport of the regolith occur due to meteoritic and micrometeoritic impacts and a number of other processes [e.g., 1]. There is no doubt that a similar regolith layer exists on Mercury. Indirect evidence suggests that it is thicker than on the Moon [2-4], which likely results from a higher micrometeoritic flux [5,6] and is consistent with a higher degradation rate of kilometers-size craters [7]. Regolith-related processes form meter- and dekameter-scale surface morphology. Here we compare small-scale regolith-related morphology of Mercury against the Moon.

High-resolution MDIS images: Toward the end of the mission, in Feb. – Apr. 2015, the MESSENGER orbiter acquired a set of images of the surface of Mercury at a very high resolution with the MDIS NAC camera [8]. The surface sampling reaches 0.7 m/pix, comparable to the highest resolution orbital images available for the Moon (and Mars), however, individual images are small (typically, 0.25 Mpix), have a considerable amount of smear, and a low actual signal-to-noise ratio (because of short exposure times needed to keep smear reasonable). Unlike the regular (10 – 20 m/pix) NAC operation regime, consecutive images taken along each orbit do not overlap and cannot be used to produce mosaics; the distance between them (~15 km) is much greater than the image size (~0.5 – 1 km). Usually the features seen in these images cannot be recognized in the available lower-resolution context images due to a large difference in resolution and small image size. In a sense, the highest-resolution images are random samples of surface morphology.

Survey: We selected and screened all ~3000 images that have (1) sampling finer than 2.5 m/pix, (2) smear less than 10 pixels (greater smear reduces image quality too much), and (3) solar incidence angle less than 70° (for lower Sun the shadows are too large). These images are scattered in a region delimited by 40 – 70°N and 210 – 320°E and occupied mostly by intercrater plains. For comparison with these surface samples we generated similar random samples for the Moon. For each Mercury surface sample, we randomly extracted a 0.25 Mpix portion from several randomly chosen LROC NAC images [9] that have the same sampling (m/pix), the same solar illumination incidence angle, and are situated on the highlands. Then we degraded the LROC NAC image quality by introducing smear identical to that in the MDIS NAC image, and adding noise to mimic MDIS NAC quality. Examples of pairs of MDIS (right) and degraded LROC (left) images are shown in **Fig. 1**. Here we report the results of qualitative comparisons of the lunar and hermian morphologies.

Degradation of small impact craters: Generally, lunar and hermian surfaces as seen at high resolution are similar. Typical surface samples are dominated by small impact craters of different sizes (10s and 100s of meters) at different stages of degradation (**Fig. 1**). Fresh craters are deeper and have crisp rims. The majority of craters are degraded: shallow and smoothed. For the Moon small craters are thought to be in equilibrium: emplacement of new ones is balanced by obliteration of old ones by regolith gardening. The presence of the whole range of crater degradation stages in each image suggests that the same occurs on Mercury, as expected. On both bodies, the apparent density of discernable craters varies from site to site to a great extent; at least partly this is caused by the occasional sampling of clusters of secondary craters. For the Moon the variations of equilibrium crater density away from secondary clusters have been documented quantitatively in [10]. On average, the crater density on Mercury seems lower than on the Moon (in **Fig. 1** Mercury is on the right), which would be consistent with a higher degradation rate [7]; however, this should be analyzed in more detail in a quantitative manner.

Elephant hide texture: It has long been known that on the Moon regolith-covered slopes, both steep and gentle, have a specific subtle dekameter-scale pattern dubbed “elephant hide” or “leathery” texture [e.g., 11-13] (**Fig. 2**). Its visibility and apparent anisotropy depends on illumination geometry [11]; small fresh craters are superposed on it. Its origin is unknown; however, it is almost certainly related to regolith transport. On Mercury, such a pattern is typically **not** observed. The illumination geometry on all surveyed images is favorable for its identification; suitable slopes might be less abundant, but certainly are present; our experiments with lunar images with degraded resolution and quality showed that the lunar texture would still be observable, if its characteristic spatial scale is up to ~8× shorter (for example, if the spacing is inversely proportional to gravity, we would still see the pattern). On rare occasions we do observe a pattern similar to the lunar elephant hide texture, but with somewhat shorter characteristic spatial scale (**Fig. 3**). In the absence of context images, it is difficult to distinguish, whether this pattern occurs on slopes and is absent on horizontal surfaces (as on the Moon), or not. Whatever mechanism routinely produces the elephant hide pattern on the Moon, it does not operate in the same manner everywhere on Mercury.

Unusual features: As we noted above, typical surfaces on both the Moon and Mercury bear a population of progressively degrading small craters, and the only crisp features with sharp slope breaks are tiny fresh craters (Fig. 1-3). The absence of craters and the presence of crisp small-scale features indicates geologically recent processes and either a very thin regolith layer or its recent significant disturbance. On both the Moon and Mercury, large geologically recent impacts produce a rich set of such morphologies. In addition, such fresh, crisp morphologies possess irregular mare patches [14,15] on the Moon and hollows [16] on Mercury.

We found one more type of fresh crisp morphologies on Mercury, "Finely-Textured Slope Patches", FTSP. The best examples are shown in **Fig. 4 and 5**; there are ~10 more images with similar features; additionally, there are several images with ambiguous FTSP identification. FTSP are patches of finely (meter-scale) textured slopes with sharp outlines. FTSP occur amid typical intercrater plains and old impact basins; there are no large young craters or hollows nearby; there are no resolvable albedo or color peculiarities close to FTSP locations. All FTSP examples found are in the southern half of the surveyed region; however, given the small number of features found, this can be coincidental. Slopes bearing FTSP have different orientations; however, they avoid north-facing directions, which again could be coincidental. FTSP often occur in groups (**Fig. 5**); in this case they occupy slopes of the same orientation. The sizes of the groups are unknown; an image located 15 km from Fig. 5 does not contain such features.

As far as we know, features such as this have not been detected on the Moon. Steep slopes of large Eratosthenian-age impact craters are free of small craters due to active mass wasting and display somewhat similar texture, but with much larger spatial scale. Those textures, however, do not form isolated sharply outlined patches and they occur on steeper slopes.

Crispness of morphology and the absence of superposed small impact craters suggest recent formation of FTSP. The formation mechanism is not clear. There is some similarity of FTSP morphology to small terrestrial landslides, and this could suggest recent massive regolith sliding. Possible present-day seismic activity might trigger such slides on Mercury, and not on the Moon. It is not clear, however, why FTSP in groups occur on slopes of the same orientation. The terrestrial mechanism of small slide formation often involves soil saturation with water and cannot work on Mercury. The latitude and orientation preferences mentioned, if not coincidental, suggest the role of high day-time temperature in FTSP formation. New data from the upcoming BepiColombo Mission will provide insights into regolith features and processes on Mercury.

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