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Reflectance of Mercury and the Moon

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Abstract

A comparison of reflectance of the Moon and Mercury was made on the basis of photometrically corrected monochrome mosaics of comparable wavelengths (566 and 560 nm) from the Lunar Reconnaissance Orbiter Camera and Mercury Dual Imaging System, respectively. Immature materials on both bodies are units least affected by space weathering, and consequently immature materials of a given composition should have similar reflectance values on the two bodies. We find that immature lunar highland materials have reflectances that are a factor of ~1.6 larger than analogous materials on Mercury. The markedly darker immature material on Mercury may indicate a compositional difference from the lunar highland surface.

1. Introduction

The albedo of airless silicate bodies, such as the Moon and Mercury, is dominated by surface composition and the state of soil maturity. The rate of soil maturation processes on Mercury is thought to be greater than on the Moon [1, 2]. Since little is known of Mercury's surface composition, comparison of the albedo between the two bodies can provide a first-order constraint for models of Mercury's composition. To lessen complications introduced by space weathering we compared the reflectance of the most immature crater populations (Copernican and Kuiperian) on each body. These craters have high-albedo rays and continuous ejecta blankets as a result of the excavation from depth of relatively immature material and its deposition onto the surrounding mature terrain. Rays of this type are known as immaturity rays, in contrast to rays visible because of compositional differences [3]. Over time, space weathering reduces the albedo of an immaturity ray, so that it approaches the reflectance of surrounding mature material. A detailed comparison of the normalized reflectance of immature and mature material on each body provides a means to constrain compositional models and investigate rates of weathering.

2. Methods

Reflectances for Copernican materials are measured from a Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC) 566 nm mosaic projected at 1000 m/p. Corresponding Kuiperian material values were taken from the Mercury Dual Imaging System (MDIS) 560 nm flyby mosaics (5000 m/p) and orbital mosaics (1000 m/p). Images composing all three mosaics were corrected to 30° phase angle using a simplified Hapke function [4,5]. To minimize photometric correction errors, only craters between 40°S and 40°N latitude were considered on each body. Also, areas imaged with only large incidence angles were excluded. Measurements of normalized, i.e., photometrically corrected, reflectance were obtained by averaging a group of pixels (at least 5x5). Sun-facing slopes were avoided while collecting the reflectance values. For this study, 33 lunar Copernican craters >20 km in diameter [6, 7] were examined. Kuiperian craters were identified by the presence of high-albedo rays and geologic context. Over 50 Kuiperian craters were identified, including 20 craters >20 km in diameter. Central peaks were avoided, and if the size of the crater permitted, two areas were measured. Similarly, reflectance measurements of the continuous ejecta blankets were taken from two areas. Additionally, the normalized reflectance of low-albedo materials [8] on Mercury was measured using only the orbital MDIS data. Twenty separate areas of low-albedo material were measured.

3. Results

Continuous ejecta blankets of Copernican highland craters have normalized reflectances ranging from 0.08 to 0.21 (average 0.15, standard deviation 0.03, n=20) (Fig. 1). For comparison, average mature lunar highlands reflectance is 0.11 (standard deviation 0.01). The normalized reflectance of the continuous ejecta blankets of Kuiperian craters (Mercury) ranges from 0.06 to 0.13 (average 0.09, standard deviation 0.01, n=23). Average mature Mercury material has a reflectance of 0.06 (standard deviation 0.01).

Areas of low reflectance on Mercury have a normalized reflectance of 0.043 ± 0.002 (n=20). One case of low-reflectance material on the outside rim of a small Kuiperian crater (9.0°S, 254.61°E), has a reflectance of 0.07, but this outlier may be attributed to scattered light from the high-reflectance ejecta blanket, or possibly mixing with underlying immature material. Compared with the average reflectance of lunar maria, 0.06 ± 0.01, mercurian low-reflectance material is darker. Southeastern Mare Vaporum has an average reflectance (0.04 ± 0.01) similar to that of mercurian low-reflectance material.

4. Summary and Conclusions

The reflectance of average immature material on the Moon is a factor of ~1.6 greater than that of average immature material on Mercury. What is responsible for this difference in albedo? Either Mercury's surface differs in average composition from the lunar highlands or there are no truly immature materials exposed on Mercury. There is independent elemental remote sensing evidence from MESSENGER [9] that the former is the case, but we cannot rule out a contribution from the latter possibility. The youngest craters (those least affected by space weathering) are those highest in reflectance (excluding compositional rays). A ratio of reflectance values for the highest-reflectance craters identified thus far on the Moon to those on Mercury is 1.6, similar to the ratio for average immature material on the two bodies. These observations are in agreement with earlier findings [10,11], but they are based on a larger sample area on Mercury and a better correspondence of camera bandpasses. We observe a larger standard deviation (±0.03) for lunar immature craters than for the population of immature craters on Mercury (±0.01), consistent with a faster rate of maturation on Mercury for a given material on each body.

Spectral measurements on thermally cycled laboratory samples [12] have suggested that the reflectance of immature soils on Mercury may be less than for similar soils on the Moon because of the magnitude of Mercury's diurnal thermal cycle. Although this might explain the difference in reflectance in immature materials, we measured a difference in mature materials as well, with the average mature lunar highland material a factor of ~1.8 higher in reflectance than mature cratered terrain on Mercury. This difference could be compositional, unless soils on Mercury reach a much higher level of maturity than those on the Moon. Whether this last possibility is correct is a key question that will continue to be investigated with MESSENGER observations.

Further investigation of space weathering with the LROC and MDIS datasets should include a comparison of smaller Kuiperian and Copernican craters (including the population of craters <20 km in diameter), and further work on relative impact flux rates may help to tighten constraints on space weathering rates on Mercury. Future comparisons of the reflectance of the Moon and Mercury will benefit from the increase in coverage and resolution of orbital color data from MDIS and as the absolute and photometric calibrations improve.

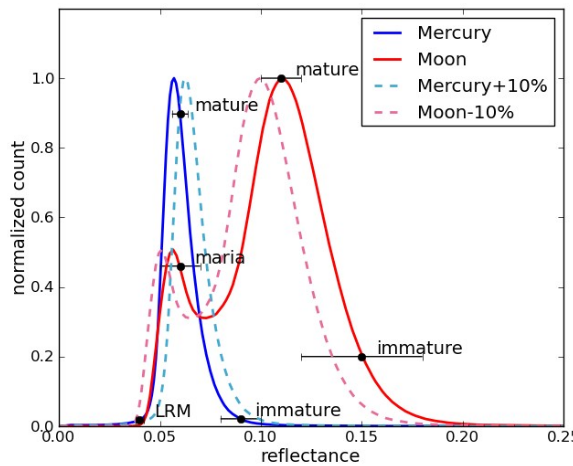

Figure 1. Histogram of reflectance values. Counts are normalized to 1.0 at the mode, and errors shown are ±1 standard deviation. Dashed lines show the worst-case uncertainty (±10%) for reflectance on the basis of absolute calibration requirements, indicating that differences in the distribution of reflectance between the Moon and Mercury are robust.

References

[1] M. J. Cintala, *J. Geophys. Res*., 97, 947-973 (1992). [2] S. K. Noble and C. M. Pieters, *Solar Syst. Res.*, 37, 31-35 (2003). [3] B. R. Hawke et al., *Icarus*, 170, 1-16 (2004). [4] H. Sato, et al. *Lunar Planet. Sci.*, 42, 1974 (2011). [5] D. L. Domingue et al. *Planet. Space Sci.,* in press (2011). [6] J. A. Grier et al., *J. Geophys. Res*., 106, 32847-32862 (2001). [7] D. E. Wilhelms, *U.S. Geological Survey Professional Paper* 1348 (1987). [8] B. W. Denevi, et al., *Science*, 324, 613-618 (2009). [9] R. D. Starr et al., this meeting, 2011. [10] B. W. Denevi and M. S. Robinson, *Icarus*, 197, 239-246 (2008). [11] G. M. Holsclaw et al., *Icarus*, 209, 179-194 (2010). [12] J. Helbert, et al., *Eos Trans. AGU*, *Fall Mtg. Suppl.*, U21A-0026 2008.