ALBEDO OF IMMATURE MERCURIAN CRUSTAL MATERIALS: EVIDENCE FOR THE PRESENCE OF FERROUS IRON. B. W. Denevi and M. S. Robinson, Arizona State University, School of Earth and Space Exploration, Box 871404, Tempe, AZ 85287-1404, bdenevi@ser.asu.edu.

Introduction: The albedo of an airless silicate body such as Mercury is dominantly controlled by two factors: composition and state of maturity. The composition of Mercury's crust is not well known, though it has been suggested to be low in FeO, similar to the anorthositic material of the lunar farside [1,2]. The space weathering environment on Mercury has been predicted to be more intense than that of the Moon, resulting in a more mature regolith [3,4]. Identifying and interpreting occurrences of unweathered material (immature or fresh) allows more confident interpretations of the nature of crustal materials. Here we compare immature lunar highlands material and immature mercurain highlands material to test the hypothesis that they share the same composition [1,5-9].

Mosaicking and Calibration: We utilized a calibration scheme to process the Mariner 10 clear filter (490 nm) images such that precise quantitative measures of albedo can be determined. Prelaunch flat field images acquired at varying exposure times provide a nonlinearity and sensitivity nonuniformity correction while an average of inflight images of deep space correct system offset [10,11]. We utilized low contrast Mariner 10 images of the venusian atmosphere to identify vidicon blemishes and create a secondary nonuniformity correction. Excessively noisy pixels were identified based on local area statistics and replaced with the average of surrounding values.

The images were taken over a wide range of phase angles (40-118°) thus requiring normalization to common photometric geometry by applying Hapke modeling [12,13], with parameters derived for Mercury [14]. Uncertainties in the actual exposure times (vs. commanded shutter time [15], and/or recorded times) were accounted for by mosaicking each set of images with like exposure times separately. Regions of overlap between these same-exposure mosaics were used to normalize all data to the same exposure time. The resulting photometrically normalized mosaic is composed of five hundred clear filter images with native angular resolutions ranging from 0.4 to 1.2 km/pixel resampled and reprojected using a bilinear interpolation to a sinusoidal projection at 1.0 km/pixel. Comparison of areas of overlap of calibrated images taken at varying exposure times indicates that the precision of the relative calibration is better than 3% for the majority of the map, and usually better than 1%. Absolute calibration was obtained through comparison with Earth-based telescopic measurements which show Mercury's geometric albedo is 0.14 at 550 nm [14,16,17]. This was adjusted adjusted to 0.12 at 490 nm based on the spectral slope of Mercury [6,18].

Range of albedo: Albedo contrasts on Mercury are significantly less than the lunar nearside but comparable to lunar highland regions with no mare. Of the imaged surface of Mercury, 82% lies within plus or minus one standard deviation of the mean albedo (Fig. 1). Two types of low albedo materials are identifiable: an annulus around crater Basho (0.09) and units exhibiting diffuse boundaries typically overlain by smooth plains material (0.08-0.10). High albedo materials fall in three classes: those associated with recent Kuiperian impacts (0.18-0.23), enigmatic small scale deposits associated with crater floors (up to 0.28), and the smooth plains unit, Borealis Planitia (0.16). Typical smooth plains have a range of albedo values similar to the global average.

Comparison with lunar reflectance: To facilitate a direct comparison with lunar reflectance values, an alternate photometrically normalized reflectance (30° phase) mosaic of Mercury was created, with its absolute calibration set relative to lunar reflectance. First, to match the spectral response of the Mariner 10 clear filter, a 490 nm image of the Moon was interpolated as a weighted average of Clementine 415 and 750 nm reflectance values. The lunar nearside reflectance average in this 490 nm image is 0.109 (30° phase). Telescopic observations indicate that Mercury's geometric albedo is ~15% lower than the lunar nearside [17], thus the Mariner 10 normalized reflectance mosaic (30° phase) was scaled to an average of 0.093.

The range of reflectances on Mercury is much

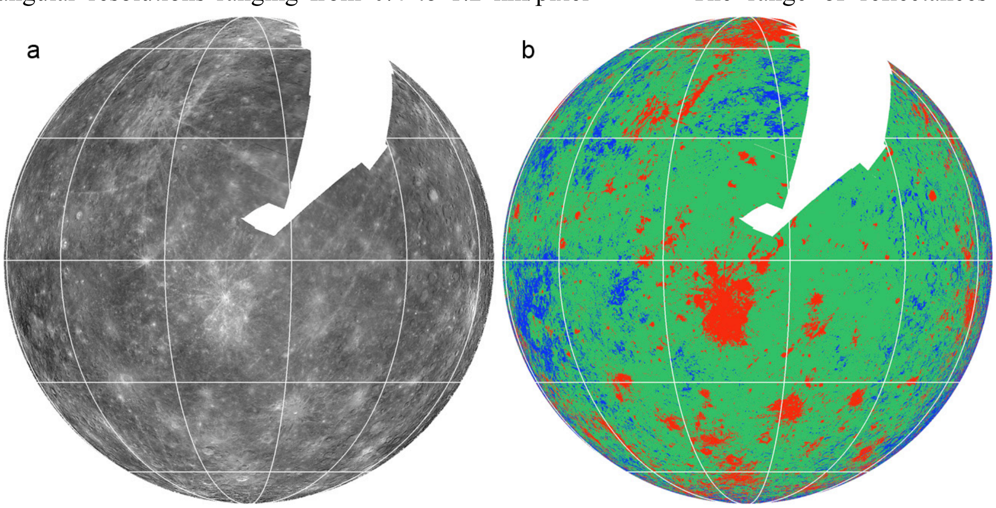

Fig. 1. a) Photometrically normalized mosaic of Mercury. b) Highlighted to indicate deviations from average albedo. Green: albedo within one standard deviation of the mean (0.12 ± 0.028); red: plus one standard deviation; blue: minus one standard deviation.

more restricted than the bimodal distribution of the lunar nearside (highlands and mare; Fig. 2). The average reflectance (490 nm, 30° phase) of typical heavily cratered mature mercurian terrain is 0.095, compared to 0.154 for typical farside mature lunar highlands (490 nm, 30° phase). The reflectance of mature lunar mare is generally 0.06-0.08, and the reflectance of mature mercurian smooth plains (morphologically similar to lunar mare) is typically 0.08-0.10. The ratio of the reflectances of the two mercurian terrain types is ~1.0, whereas on the Moon the highland/mare ratio is ~2.0. Copernican craters (immature) on the Moon have reflectances from ~0.20 to 0.26, whereas Kuiperian craters on Mercury range from 0.13-0.18. Reflectance of immature lunar material is ~1.7× higher than mature lunar highlands, and immature mercurian material is ~2.0× higher than its mature counterpart. The reflectance of immature lunar material is ~1.5× that of analogous mercurian material.

Discussion and conclusions: The ratio of immature crater ejecta to average mature material is ~2.0 on Mercury, compared with ~1.7 on the Moon, indicating the mercurian regolith is reaching a relatively higher state of maturity, as expected based on its surface temperature, higher rate and speed of impact, and calculations of melt and vapor production on the surface [3,4]. The higher rate of weathering implies that the age of the base of the Kuiperian system is younger than the age of the Copernican system on the Moon, due to the increased rate of weathering of rayed craters. This higher state of maturity also hinders the interpretation of spectral reflectance measurements of Mercury.

However, one way to avoid the complicating effects of space weathering is to compare the reflectance of immature material on Mercury and the Moon – immature material of the same composition should have the same reflectance on both bodies. Immature highland material on the Moon (0.26) has reflectances

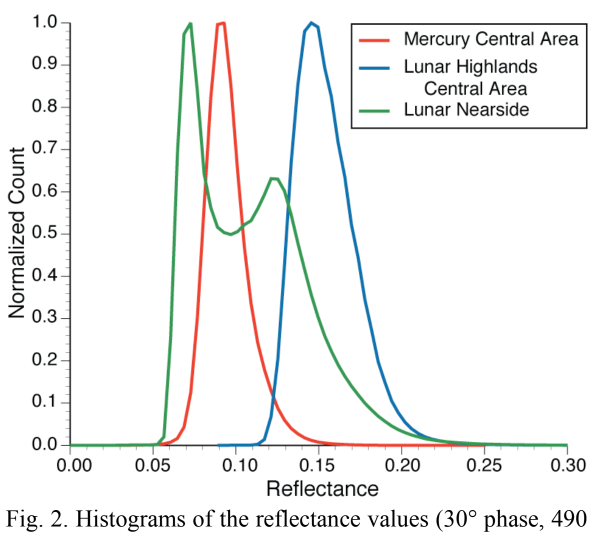

Fig. 2. Histograms of the reflectance values (30° phase, 490 nm) in a typical portion of the mercurian cratered terrain (red), lunar farside highlands (blue) and lunar nearside (green: excluding latitudes poleward of 70°).

~1.5× higher than analogous immature material on Mercury (0.18). Thus by this comparison Mercury's crust must contain some significant darkening agent – opaque minerals, or most likely FeO, considering the red continuum slope in the visible and near-infrared. If FeO were the culprit then the content of the mercurian crust would thus be higher than typical farside lunar highlands materials (3-4 wt% FeO), and perhaps equal to or greater than the upper estimates of 6 wt% FeO for Mercury [1,19-21].

Such higher FeO abundance is seemingly in conflict with interpretations of near-infrared telescopic spectra of Mercury that lack definitive absorptions due to Fe-bearing minerals and are similar to spectra of lunar highland anorthositic material [e.g. 1,22]. However, we note that absorptions attributed to ferrous iron in pyroxenes have been observed in some spectra [2,19] and even spectra of relatively mafic lunar highland regions, such as the Apollo 16 site, have very shallow 1 µm absorptions, which would be even further decreased for Mercury due to the increased space weathering environment.

If the crustal composition of both Mercury and the Moon is similar, the relative calibration presented above (Mercury's reflectance 15% lower than the lunar nearside) must be in error otherwise immature material on the two bodies would have the same reflectance. Correcting the reflectance map such that the reflectance of the mercurian immature materials matches that of its lunar counterpart results in Mercury's average reflectance being unrealistically high - 27% greater than the lunar nearside. While there remains a degree of uncertainty in the relative refectances of the two bodies, estimates of albedo from a large number of workers do not support a finding that the global average for Mercury is higher than the lunar nearside average [e.g. 17].

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