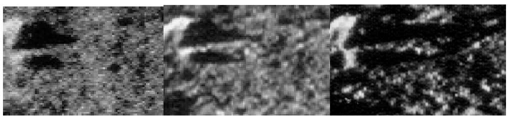
Microsymposium 38, MS082, 2003
(A4 format)

EVALUATING THE STRUCTURE OF THE SURFACE LAYER OF MERCURY.

V.V.Shevchenko, Sternberg State Astronomical Institute, Moscow University, Moscow 119992, Russia, shev@sai.msu.ru

Introduction. Like all atmosphereless bodies, Mercury is likely to be covered by a regolith layer that was formed in the process of space weathering. In addition, typical processes of space weathering (meteorite and micrometeorite bombardment, solar insolation, temperature changes, and others) must have their specific consequence in the case of Mercury. The ultimate result of these processes - the regolith structure - may indicate to what extent the individual features of Mercury's environment affect the formation of the surface layer. The ESA BepiColombo project plans to launch a spacecraft that will carry a lander to examine the surface of the planet, thus providing a direct study of the structure of its surface layer [1]. This is an appropriate time to make a preliminary assessment, using remote sensing data and taking into account the known similarity of the surface structures of Mercury and the Moon.

Photometric Analysis of the Lunar Surface Analogue. Based on the postulate of the identity, to a first approximation, of the photometric properties of the Moon and Mercury, one can represent the model of the surface layer of the regolith of Mercury using real images of the surface layer of the lunar regolith. The fragments of panoramas of the surrounding landscape transmitted to the Earth by the unmanned Luna 13 station [2] were selected for analysis. The advantage of these materials for photometric processing is their uniformity. Identical fragments of three panoramas obtained at different angles of incidence of solar rays were used. The operating range of reflection angles was 65^o - 80^o, while the range of azimuth angles was confined within the range 70^o - 85^o. This allowed the values of the measured phase function to be obtained in the range of phase angles from about 70^o to 75^o. The images of exactly the same site obtained at three different angles of incidence of solar rays (the values of the angles are indicated in the figure caption) are given in Figure 1. These images demonstrate how the shadowed area changes together with the total brightness of this area. The smallness of the total area where measurements were made suggests that the upper regolith layer exhibits no albedo variations, except for some stony fragments. The value of the measured integral brightness of each area was inferred from the average value of the image density (using a histogram). The resulting values were then reduced by the least squares method to the system of relative brightness specified by the phase function of the Moon or Mercury.



a b c

Fig. 1. Images of the same region of the lunar surface taken at different angles of incidence of solar rays: (a) i = 58.4^o; (b) i = 62.7^o; (c) i = 68.2^o. The reflection angle is 76.5^o for all images. The approximate size of the each site is 10 cm by 10 cm.

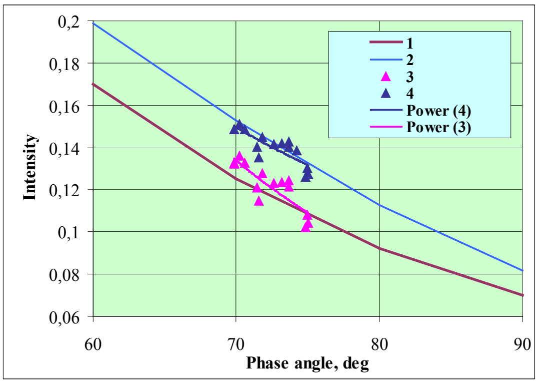
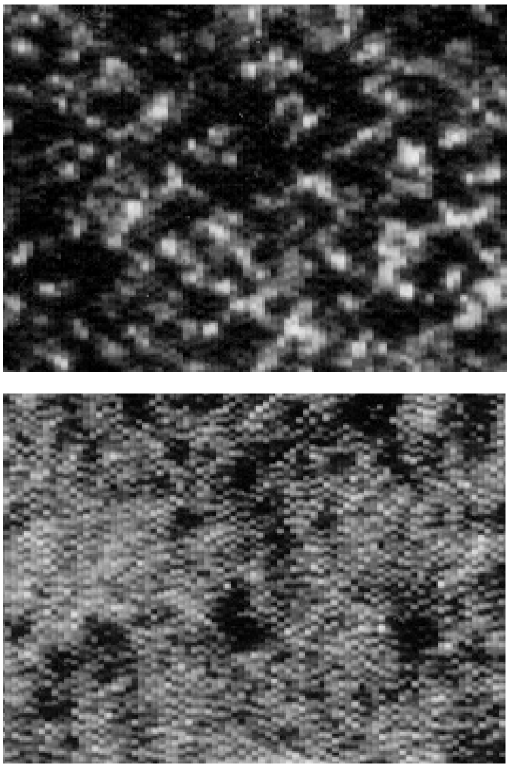


Fig. 2. The phase function obtained directly on some segments of the lunar surface: 1- phase function of the Moon, 2 - phase function of Mercury, 3 - phase function of segments, converted to the lunar phase function system (correlation 0.8), 4 - phase function of segments, converted to the Mercurian phase function (correlation 0.9).

The results of the observations and model comparison are shown in Figure 2: the fragments of the phase functions of the Moon and Mercury are given for phase angles from 60^o to 90^o, and some phase brightness values (triangles) match the determinations from the panoramas obtained directly on the lunar surface and reflect the photometric properties of the surface layer of the lunar regolith. It should be noted that the sample of areas for measurements, which is obtained in a random way, unexpectedly closely correlates in terms of the variation of phase brightness with the Mercurian phase function and less closely with the phase function of the Moon.

The Luna 13 landing site (63.05^{o}W, 18.87^{o}N) is located in the region of intense bright rays corresponding to the ejecta from the young Glushko crater. It is likely that this circumstance explains the anomalous character of the photometric properties of the lunar surface in the region of interest, with the properties of the mantling substance approaching the reflectance properties of Mercury's surface.

Model of the Mercurian Surface Layer. Since an increase in brightness (see Figure 2) is accompanied by the general smoothing of the surface due to the destruction of larger irregularities and to the growth of the relative content of the thin regolith fraction [3], the above estimates of the roughness of the Mercurian regolith agree with the inference made above on the basis of the photometric analysis: the surface of the Mercurian regolith is smoother than the surface of the lunar regolith.



a

b

Fig. 3. Comparison of the real lunar surface structure (a) and the modeled Mercurian surface structure (b).

Figure 3 represents the result of modeling the surface structure of the Mercurian regolith layer on the basis of the lunar unit using the photometric properties shown in Figure 2. The lunar regolith upper layer is more rough than the modeled surface layer of the Mercury regolith (b). The picture (b) represents a possible view of the Mercurian surface under the same illumination. This modeling was performed by means of the decreasing shadow area algorithm. The phase function of segments such as (b) coincides with the disk – integrated phase function (see Figure 2). Therefore, the surface whose image is presented in Figure 3b may tentatively serve as an analogue of the structure of the upper layer of the Mercurian regolith.

Conclusions. The method described and the results of some remote ground-based investigations of Mercury show that the similarity of the surface structure of this planet to the Moon's surface can be used to obtain preliminary estimates of the structure and characteristics of the Mercurian regolith. Although in general similar to the Moon, the surface of the Mercurian regolith is nevertheless smoother, probably contains a greater amount of the fine particle size fraction, and has, on average, greater maturity. The results presented and their further modification are also of applied significance in planning and implementing the aforementioned space projects.

Acknowledgement. This work was supported by INTAS-ESA grant No. 99 – 403.

References: [1] Grard, R., and T. Mukai, (2001) in *Mercury: Space Environment, Surface, and Interior,* The Field Museum, Chicago, Illinois, October 4 - 5, 2001, Abstracts, 8024. [2] *The First Panoramas of the Lunar Surface*, (1969) (in Russian). [3] McKay, D.S. et al., (1995) in *Lunar Sourcebook*, Cambridge: Cambridge Univ. Press, 285-356.