LUNAR TOPOGRAPHY: EVIDENCE FOR GLOBAL SCALE LATERAL DENSITY VARIATIONS. Bruce G. Bills and Alfred J. Ferrari, California Institute of Technology, Pasadena, California 91125.

A new determination of global lunar topography has been made by fitting an eighth degree and order harmonic model to 5800 Apollo laser altimetry (1) points (σ = 0.3 km.), 1400 Apollo photogrammetric (2) points (σ = 0.3 km.), and 3300 earth-based photogrammetric (3, 4, 5) points (σ = 1.0 km.). The earth-based observations have been corrected to the center of mass coordinate system used for inertial data (6). The center of figure of this model is displaced from the center of mass of the moon by 1.77 ± 0.16 km. toward 25° south and 191° east. The components are:

\[ \Delta x = -1.57 \pm 0.08 \text{ km.} \]
\[ \Delta y = -0.30 \pm 0.04 \text{ km.} \]
\[ \Delta z = -0.75 \pm 0.13 \text{ km.} \]

The mean radius was determined to be 1737.46 ± 0.04 km. The principal semi-axes of the best fitting triaxial ellipsoid are:

\[ x' (23°S, 20°E) = 1738.04 \pm 0.09 \text{ km.}, \]
\[ y' (33°N, 94°E) = 1737.68 \pm 0.06 \text{ km.}, \]
\[ z' (48°N, 317°E) = 1736.67 \pm 0.13 \text{ km.} \]

Radial variations evaluated over the lunar surface (Figure 1) show that basalt filled, ringed basins larger than 300 km. in diameter are predominantly at or below the mean radius, whereas their unfilled counterparts are consistently above the mean radius. This suggests filling to a common hydrostatic level (7). There appears to be a general tendency for the older basins in a given size range to be at lower elevations than the younger basins. The lunar farside is characterized by broad highland regions attaining elevations of 5 km. above the mean radius. A large farside depression (2.9 km.) is centered at approximately 30°S and 185°E. This depression, which is nearly antipodal to Mare Imbrium, coincides with the greatest concentration of filled basins on the farside.

The displacement between centers of mass and figure implies an asymmetry such as would be produced by a greater crustal thickness on the lunar farside (8). This would also explain the paucity of farside filled basins.

For a body in which the density distribution is laterally homogeneous, the harmonic coefficients of gravity and topography are directly proportional (9). Figure 2 shows the harmonic spectrum of the actual topography compared with equivalent topography derived from a lunar gravity model (10), in terms of the integrated R.M.S. contribution of each harmonic. From this comparison, several interesting conclusions may be drawn. First, the dominant aspect of lunar topography is the first degree center-of-mass, center-of-figure offset. Second, ellipsoidal figures are inadequate to model the global features of the moon since the contributions of the third and fourth degrees are larger than that of the second degree. Finally, the gravity and topography are anticorrelated (correlation coefficient = -0.7), implying that global scale lateral density inhomogeneities exist on the moon.
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References

(2) NASA, 1974, Lunar Topographic Orthophotomaps, Scale 1:250,000.

Figure 1. Lunar topography in 0.5 km. contour intervals.

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Figure 2. Lunar topography spectrum.