APOLLO LASER ALTIMETRY AND INFERENCES AS TO LUNAR STRUCTURE, W.M. Kaula, G. Schubert, R.E. Lingenfelter, Univ. of California, Los Angeles 90024; W.L. Sjogren, Jet Propulsion Laboratory, Pasadena, Calif. 91103; and W.R. Wollenhaupt, NASA Johnson Space Center, Houston, Texas 77058

The Apollo 17 altimeter worked excellently, and obtained 12 revolutions of data. For most of the nearside features, the altitudes are reasonably close to those measured by Apollo 15 (1) where the ground tracks are within about 200 km of each other. The elevations of Mare Serenitatis and the two adjacent maria, Imbrium and Crisium, are virtually the same in the Apollo 17 data as in the Apollo 15. The Appenines and Taurus Mountains also have about the same elevations in the two orbits. However, further west there is some divergence; the Carpathian Mountains show up in the Apollo 17 data, and Oceanus Procellarum is perhaps 0.5 km lower under Apollo 17 than under Apollo 15. Two pronounced features unique to the Apollo 17 data are the deep craters Reiner and Neper, with depths of 5 and 6 km, respectively, below the 1738 km sphere. For a crater as small as Reiner (25 km diameter) this depth is quite remarkable.

On the farside the appearance of the Apollo 17 profile is also similar to that of Apollo 15, but since the terrain is so much rougher, only a qualitative comparison can be made. Apollo 17 also shows a considerable depression around 180° longitude, but not quite as broad or as deep as shown by Apollo 15; the greatest depth is not quite 4 km below the 1738 km sphere. A best fit of a circle to the zero elevations on the Apollo 15 and 17 tracks obtains 950(±120) km for the radius and 45°(±4°)S, 181°(+5°)E for the center of this basin.

The Apollo 17 ground track intersects that of Apollo 16 (2) at an angle of 40° near longitudes 100°E and 80°W, both in terra terrain. Nonetheless, the two profiles agree within one-half km in these regions.

The mean radius and offset of center-of-figure from center-of-mass of the Apollo 17 track furthest from Apollo 15's track are similar to those from Apollo 15 (2):

Track	Mean radius km	Offset km	Direction
Apollo 15	1737.3	-2.1	25°E
Apollo 16	1738.1	-2.9	25°E
Apollo 17	1737.4	-2.3	23°E
Weighted mean	1737.7	-2.4	24°E

In this weighted mean, double weight was given to the Apollo 16 values and single weight to the Apollo 15 & 17.

The Apollo 17 data obtained similar results to the earlier flights for the mean elevations by terrain type:

LASER ALTIMETRY

Kaula, W.M. et al.

Terrain Type	Portion of Global Surface	Apollo 15 Track km	Apollo 16 Track km	Apollo 17 Track km	Weighted Mean km
Farside Terrae	.57	+1.9	+2.1	+0.9	+1.8
Nearside Terrae	.23	-1.7	-1.2	-1.3	-1.4
Ringed Maria	.06	-4.1	-4.1	-3.7	-4.0
Other Maria	.14	-2.0	-2.5	-2.1	-2.3
Global Mean	1.00				+0.2

The weighting ratio is again 1:2:1. In calculating the portions of the global surface for each terrain type, some nearside regions were classified as "farside terrae": essentially, those areas dominated by pre-Imbrium terra and crater materials on the geologic map (3), south of a line varying about 40°S and north of 70°N.

In addition to the larger mean radius of 1738.2 km, global extrapolation by terrain type gives a different offset of center-of-figure from center-of-mass: -2.3 km in the direction 13°N, 3°W. This southward displacement agrees well with the estimate based on occultations (4).

The seismologically determined crustal thicknesses of 20 km mare basalt above 40 km of anorthositic gabbro appear to be representative of eastern Oceanus Procellarum (5). Assume that (a) the mean crustal thickness is 40 km under the "other maria" terrain type, (b) ringed maria have a mean mass excess equivalent to 2.5 km of basalt (6), (c) other terrain types have zero mass excess or deficiency, and (d) the mean density difference between basalt and anorthositic gabbro is 0.4 g/cm^3. Then from the weighted mean elevations by terrain type the mean crustal thicknesses are calculated to be 74 km under farside terrae, 48 km under nearside terrae, and 5 km under ringed maria. The global mean is 61 km. Assuming this global crust to have 2.95 g/cm^3 mean density, the balance of the moon must have 3.39 g/cm^3 mean density. Finally, if the moon below this crust were of uniform density, the moment-of-inertia ratio I/MR^2 would be 0.3968.

The lunar ranging project has obtained values of 630.6 (±0.5) $\times 10^{-6}$ for β, $(C-A)/I$, and 226.0 (±3.0) $\times 10^{-6}$ for γ, $(B-A)/I$ (7). The ranging project has also obtained from the physical librations values for the third harmonics which confirm the results of Sjogren (8) much better than other solutions. This confirmation indicates Sjogren's second harmonics--204.8 (±3.0) $\times 10^{-6}$ for J_2, $(C-A/2-B/2)/MR^2$, and 22.1 (±0.5) $\times 10^{-6}$ for J_{22}, $(B-A)/4MR^2$--are probably the best. The formula in (9) then obtains a plausible range for I/MR^2 of 0.3957 ± 0.0059 to 0.3949 ± 0.0050. A fair compromise, allowing for the redundancy of data, is 0.3953 ± 0.0045 (standard deviation).

LASER ALTIMETRY

Kaula, W.M. et al.

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