LUNAR SHAPE AND TOPOGRAPHY FROM THE APOLLO LUNAR SOUNDER*

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Elevation profiles have now been extracted from the Apollo Lunar Sounder 5MHz (60 meter wavelength) radar data for two complete revolutions of the Moon. The profiles have been corrected for a later-generation spacecraft ephemeris than was available when the first rev of data was presented at the Fifth Lunar Science Conference (Brown, et al, 1974), and the effects of fades and off-nadir returns have been investigated and removed. As it turned out, the only significant inaccuracy occurred when the spacecraft flew directly over and parallel to a crater rim, where there was a weak return from the actual subspacecraft point and a strong one from the crater floor somewhat off track. The result was an apparent crater profile that appeared much deeper and narrower than the actual crater. When this occurred (5 cases) the data was deleted and appears as a small gap in the profile.

The profiles have been analyzed on two scales: global and local. On the global scale the data yield somewhat the same information about the lunar shape as the Apollo Laser Altimeter (Kaula, et al, 1974). The profiles have been curve fit to a third order harmonic function (Table I) treating the mare and highlands both together and separately, and the results are consistent with the global shape found by Bills (1975) using the Apollo Laser and Apollo and Earth-based photogrammetric data. Namely, the dominant aspect of the topography is the first degree (center of mass-center of figure offset) term, the second degree term is quite small (of the order of the orbit-to-orbit error in the ephemeris, 100 meters), and the third degree term is significant. For these orbits at least this third degree term is caused primarily by the large farside basin, which is about 60 degrees of longitude in extent. When the maria (Serenitatis, Crisium, and Oceanus Procellarum) are curve fit separately a substantial second order term appears, consistent with the result of Sjogren and Wollenhaupt (1975) for mare surfaces. This "bulge," however, should be interpreted with caution. First, the fit is not good in this case since we are dealing essentially with three short arcs of data. Since 3 points do not define an ellipse we are depending on the relative slopes of the surfaces. Second, the fit is sensitive to which data are used, i.e., when the eastern part of Oceanus Procellarum (where a slope change seems to occur) is excluded, the offset term decreases by 1.3 Km and the ellipticity increases by 0.5 Km. When the floor of the farside filled crater Aitken is included the fit changes again but by a smaller amount, so perhaps the curve fit process has some validity in this case. But third and most important, care must be taken when

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interpreting the fit as representing a global hydrostatic surface. Most researchers agree that the lunar lava was of low enough viscosity to have conformed to an equipotential surface, but for the curve fit to make sense in terms of physical interpretation this must have been the same equipotential for all maria. This requires that they flowed from the same source, were subject to the same pressure forcing lava to the surface, or were connected in some other way. Whether this could be true for lava flows separated by thousands of kilometers and hundreds of millions of years of time seems doubtful.

The major advantage of radar over other forms of altimetry is the essentially continuous nature of the profiles, allowing detailed analysis of local regions. This has been done for the relatively smooth mare surfaces where the radar return was quite strong. There are three major findings:

1. The outer 50-100 Km of Maria Serenitatis and Crisium are raised about 500 meters above the general mare level. These smooth "ledges" are sometimes sloped away from the mare by up to about 20°, and have well defined inner edges where the profile drops quite rapidly.

2. Inside the ledges the mare exhibit a slight "doming," i.e., the profile rises slowly until the central part is about 250 meters above the outer edges. This may be a result of the lave conforming to an equipotential when it was in the fluid state.

3. The floor of the farside filled crater Aitken also exhibits this doming. In this case the central bulge is about 200 meters over a crater floor diameter of 100 Km. Here the doming is more likely due to isostatic uplift, as was suggested by Elachi, et al (1975) for similar observations of Hevelius and Neper by the Lunar Sounder VHF (2 meter) relative altimetry.

References:

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TABLE I

Lunar Sounder Radar Profile Fit to Harmonic Function

$$R = \bar{R} + R_1 \cos(\lambda - \lambda_1) + R_2 \cos 2(\lambda - \lambda_2) + R_3 \cos 3(\lambda - \lambda_3)$$

$\bar{R}$	R_1	λ_1	R_2	λ_2	R_3	λ_3	COMMENTS
1737.14	-2.31	24.4	0.12	112.5	(0.0)		ALL POINTS
1737.14	-2.31	23.4	0.11	112.5	1.27	3.8	
1737.36	-2.00	23.4	0.19	72.5	(0.0)		HIGHLANDS ONLY
1737.28	-2.06	23.5	0.12	38.8	1.32	6.3	
1735.70	-1.68	23.1	0.72	-15.0	(0.0)		FRONTSIDE MARIA ONLY
1735.01	-0.38	-15.0	1.20	-33.7	(0.0)		EXCLUDING EASTERN OCEANUS PROCELLARUM
1734.68	0.10	4.7	1.04	-36.2	(0.0)		INCLUDING AITKEN

(0.0) ⇒ VALUE HELD FIXED AT ZERO

UNITS ARE KM AND DEGREES