THE THICKNESS OF THE ANCIENT LUNAR LITHOSPHERE; H.J. Melosh, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125

Melosh (1) showed that when the load of a mascon is imposed on the lunar lithosphere a distinctive tectonic pattern emerges. The mascon is approximated by a load with a gaussian profile acting on a floating elastic lithosphere. Its center is characterized by radial-trending thrust faults. This central region is surrounded by an annulus of strike-slip faults which is in turn surrounded by concentric normal faults and graben. The radius at which these tectonic provinces change character (normalized by the half-width of the gaussian load) is a strong function of the lithosphere thickness. Thus, geologic mapping, combined with gravity data on the mascon load radius, allows the thickness of the elastic lunar lithosphere to be determined at the time of mascon emplacement (ca. 3.5-3.8 Æ ago).

The concentric graben are readily seen on the lunar geologic quadrangle maps around Maria Serenitatis and Humorum. Inside the circle of these graben is an array of mare ridges (see Fig. 1 compiled from lunar geologic quadrangle maps prepared by the USGS). The precise nature of these ridges is unknown. Tjia (2) suggested that they may be indicative of strike-slip faulting, but many other interpretations have been given. The fact that they generally form in eschelon arrays, and many of them trend in directions near $\pm 30^{\circ}$ of circles concentric to basin center (Fig. 1) encourage me to suggest, mainly on the basis of the theoretical stress pattern, that they represent the response of the mare basin fill to strike-slip motion. One of the major difficulties with this interpretation in Serenitatis is that mare ridges also occur near the basin center with roughly radial trends. The same feature must thus be interpreted as the result of strike-slip motion in one region and thrusting in another.

If this difficulty with the mare ridge interpretation can be resolved, a simple picture of the basin tectonics emerges. The radius of the boundary between strike-slip and concentric normal faults is ca. 325 km in Serenitatis (254-389 km are extreme values). Combined with a mascon load half-width of 132 km from A-17 gravity profiles (3), this yields a predicted strike-slip/thrust fault transition at ca. 170 km (shown on Fig. 1 as a long-dashed circle) and a lithosphere thickness of 25 to 40 km. The ca. 240 mgal gravity anomaly implies about 400 bar of radial stress at the border of Serenitatis (probably adequate to produce the observed normal faulting), and a maximum thickness of basalt of ca. 3.5-5.5 km in the basin center, not far from the extrapolated estimates of DeHon and Waskom (4) in Serenitatis. The center of the basin subsided ca. 1 km due to partial isostatic compensation.

In summary, the moon's present elastic lithosphere is probably more than a hundred km thick, based on the support of its non-hydrostatic figure. However, when the mascons were emplaced, 3.5-3.8 Æ ago, the elastic lithosphere seems to have been between 25 and 40 km thick, similar to the thickness of earth's lithosphere today. Since the heat flow due to radiogenic heat production in the moon at that time was probably similar to that of the earth today (i.e., somewhat greater than 1 HFU), this fact should not be surprising.

ANCIENT LUNAR LITHOSPHERE

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References

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