## Early Temperature History of the Moon

Pike (*1*) has plotted the logarithm of depths against the diameters of lunar craters. The plot shows a break in this at a diameter of about 14 km, and Pike interprets this to mean that isostatic adjustment has occurred in craters of larger diameter. This implies a plastic moon of small finite strength and effective viscosity. The mascons of Muller and Sjogren (*2*) show that the circular maria are underlain with massive objects that have not become isostatically adjusted during long periods of time—presumably some 4.5 billions of years—an indication of very high strength and high effective viscosities. Turkevich *et al.* (*3*) with their particle scattering experiments have shown that the lunar surface has an approximately basaltic composition, indicating that fractionation of primitive material by lava flows or fractional crystallization have occurred and therefore that the outer parts of the moon have been plastic. The existence of mascons seems to contradict the evidence from these other observations. I believe that there is a consistent explanation for this difficulty.

In 1968, I presented a discussion of the mascon problem and related it to the difficulties posed by some meteorite problems (*4*) [see also Urey and Marti (*5*)]. Briefly, it was suggested that the moon's outer surface was melted to some depth and slowly crystallized to produce (i) material of the calcium-poor achondrite and enstatite achondrite types, and (ii) a surface layer of basaltic type material observed by Turkevich *et al.* This suggestion was based on the assumption that the moon was accumulated at low temperatures, was heated by some method at the surface early in its history, then cooled off slowly, and was bombarded by objects of the type accumulating into the earth.

Pike's observations fit this hypothesis exactly. If we assume that the intense bombardment occurred early in the history of the moon, that is, 4.5 billion years ago when the surface to some limited depth was solid but at moderately elevated temperatures, a complicated pattern would result. The outer part of the moon that has been melted and subsequently solidified could have a strength sufficient to support the depths of craters less than 15 km in diameter, but insufficient to support those of 15 to about 150 km. The cold interior would have sufficient strength to support the mascons which probably penetrated to some 50 to 100 km below the surface. Thus, the observed data lend support to a model of the moon accumulated at low temperatures, melted at the surface to some depth, possibly 50 km, and then slowly solidified and bombarded briefly by objects of terrestrial composition. The figure illustrates the physical situation.

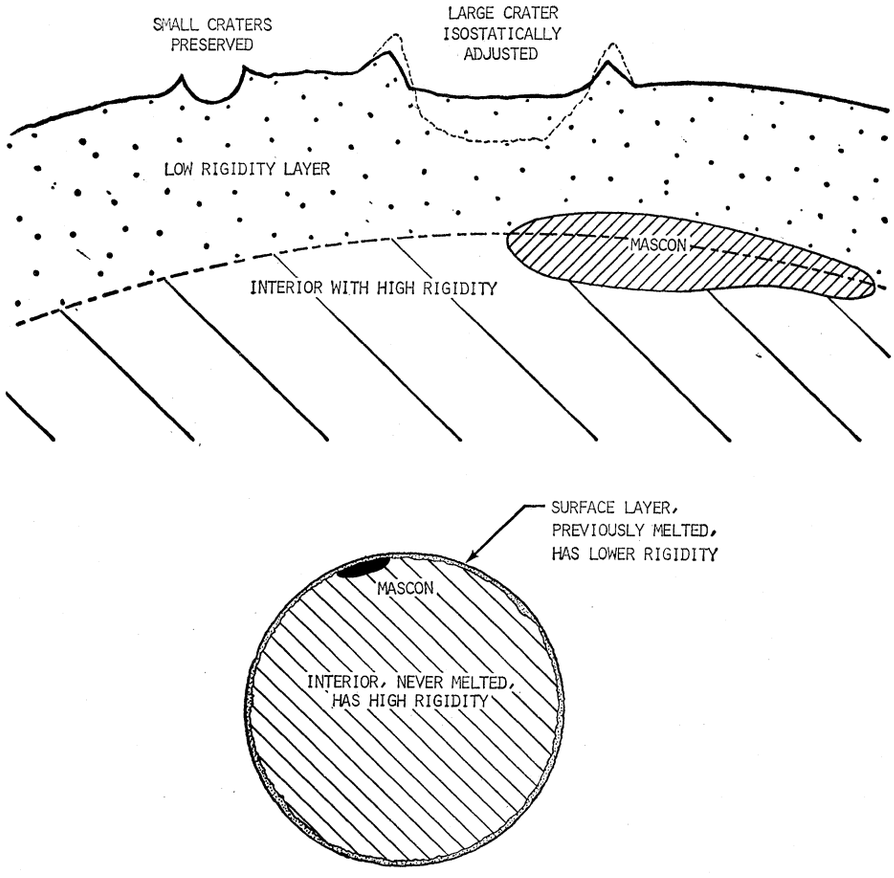


Fig. 1. Possible layering in the moon.

The explanation offered here is the same as that proposed by Pike, except that he assumed a plastic moon throughout its entire body; however, here it is assumed that only the surface layer had a low elastic limit.

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### References and Notes

1. R. J. Pike, *J. Geophys. Res.* **72**, 2099 (1967).
2. P. M. Muller and W. L. Sjogren, *Science* **161**, 680 (1968).
3. A. L. Turkevich, E. J. Franzgrote, J. H. Patterson, *ibid.* **162**, 117 (1968).
4. H. C. Urey, *ibid.*, p. 1408.
5. H. C. Urey and K. Marti, *ibid.* **161**, 1030 (1968).
6. This is contribution No. 1 from Lunar Science Institute.

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