
All global structural models of the lunar interior advanced to date based on seismic data assume that the internal structure of the moon is radially symmetrical (1,2). In constructing such models, deviations of observed seismic arrival times from those which are expected from a radially symmetrical model may be treated as statistical scatters of observational errors. As seismic data from natural events accumulate, however, it has become apparent that these deviations are not randomly distributed as would be expected if they were observational errors, but show certain systematic distributions. In addition, some observed deviations have been found to be too large to be due to an observational error. A reasonable explanation is that they represent broad-scale lateral inhomogeneities in the lunar interior. A broad-scale heterogeneity of the moon is not surprising because it is expected from such other observations as those of the shape and the gravitational field of the moon (3,4).

The following three sets of natural seismic events are being used to examine the broad-scale lateral inhomogeneity of the lunar interior.

(A) Large meteoroid impacts within 60° from the center of the Apollo seismic network. Seismic rays from these natural seismic events penetrate to depths less than about 200 km, thus supplying information on the broad-scale lateral inhomogeneities in the upper 200 km of the lunar interior. The observed deviations of seismic arrival times from those expected for a radially symmetrical moon may be evidence of lateral inhomogeneity in the crust, of lateral variations of crustal thickness, of variation of the seismic velocities in the upper mantle, or of a combination of these effects. A separation of these various effects has not yet been possible with the limited data available to date. Assuming that the lunar crust were uniform within 60° radius of the seismic network, an average upper mantle velocity may be calculated for each impact event. A preliminary result for the P-wave velocity is shown in Figure 1. Impacts north of the network generally give higher upper mantle P velocity than the average, while those in the south generally give lower velocities. This result may be interpreted as an indication of a higher upper mantle P velocity in the northern hemisphere than the southern hemisphere of the front side of the moon, or may alternatively be interpreted as an indication of a thicker crust underneath station 15 than other stations.

(B) Deep Moonquakes. Lateral inhomogeneities in the depth range from the surface to the depths of deep moonquakes (800 - 1000 km) are reflected in the seismic arrival times of deep moonquake sig-
Fig. 1. Distribution of apparent upper mantle P velocity. (Base map is the front side of the moon in an equal area projection.)
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No consistent distribution of broad-scale heterogeneity has yet been identified. This may be attributed either to the difficulty in identifying the true onsets of seismic arrivals from deep moonquakes or to the overwhelming effects of heterogeneities local to each moonquake source region.

1. Large natural events (HFT's and meteoroid impacts) at far distances. Seismic rays from these sources penetrate below 200 km depth, and thus reveal broad-scale heterogeneities in the zones below the upper mantle. Seismic arrivals are particularly sensitive to the seismic velocity variations in the middle to lower mantle (300-100 km depth range), where the seismic rays spend most of their time. A few regions have been found where either the mantle velocity is lower than those in the surrounding regions or the boundary between the middle and the lower mantle is shallower than in other regions. The existence of such lateral heterogeneities at depths near the middle/lower mantle boundary may be related to the occurrence of deep moonquakes at these depths (5).

Seismic data from the present network is not sufficient to reveal the expected structural difference between the front and the far sides of the moon.

References