P.758

VELOCITY STRUCTURE AND PROPERTIES OF THE LUNAR CRUST,

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Lunar seismic data from three Apollo seismometers are interpreted to determine the structure of the moon's interior to a depth of about 100 km. Seismic signals from three SIV-B and three LM-ascent stage impacts on the moon have been recorded over a distance range of 67 to 356 km by the Apollo 12, 14, and 15 seismometers. The travel times of the first (P) arrivals and the reflected phases are determined. The observed travel times and amplitudes are interpreted in terms of a compressional velocity model extending to a depth of 80 km inside the moon. This model is further refined by matching the observed seismograms with theoretical seismograms computed using generalized ray theory. Velocities very near the surface of the moon are determined from LM Thruster test firings and agree with Active Seismic Experiment results.

The seismic compressional velocity profile based on the combined data and interpretation techniques is shown in Figure 1. The most outstanding feature of the model is that the moon has a layered crust and the thickness of the crust at the investigated Fra Mauro region of Oceanus Procellarum is about 65 km. Other features of the velocity profile are: i) Very rapid increases at very shallow depths from a surface value of 0.1 km/sec to about 5 km/sec at the 10 km depth. ii) A sharp increase (discontinuity) at a depth of about 25 km. iii) Near constant value (about 7 km/sec) between 25 and 65 km. iv) A significant and discontinuous increase at the base of the lunar crust (65 km). v) As can be determined from a single data point corresponding to the distance of 356 km, very high velocity (greater than 9 km/sec) below the lunar crust.

The compositional implications of the velocity model are also illustrated in Figure 1. The high-pressure data of laboratory measurements on lunar and terrestrial rocks are also shown on the same plot. It is clear from the comparison that:

i) Near the surface, to a depth of about 1 to 2 km, self-compacting fines, breccias, and broken rocks can explain the velocities. Below this depth, basaltic rocks similar to those studied from Apollo 11 and 12 missions fit the velocity values to a depth of 25 km. The high

P.759

velocity gradients to a depth of 10 km result from the pressure effects on dry rocks having cracks and pores.

ii) The second layer of lunar crust seems to be distinctly different from the basaltic lunar rocks sampled from the surface. Terrestrial equivalents would range from norite to grabbro or pyroxenite or anorthosite.

iii) The mantle velocities, although tentative at this stage, are higher than most earth rocks and are close to Mg-rich olivines.

The evolution of such a lunar crust is discussed in the light of thermal history calculations and the geological properties of lunar rocks.

Figure 1. Seismic compressional velocity profile inside the moon (hatched line). Laboratory data for lunar rocks are indicated by sample number. Terrestrial rocks are numbered 0 - 7. Lunar data from Anderson, et al (1970); Kanamori, et al (1970, 1971); Wang, et al (1971); Warren, et al (1971); in Proceedings of Apollo 11 and 12 Science Conferences. Terrestrial rocks from various sources.

P.760