

LUNAR STRUCTURE, COMPOSITIONAL INFERENCES AND THERMAL HISTORY. M. N. Toksöz, F. Press, A. M. Dainty, S. C. Solomon, K. R. Anderson, Department of Earth and Planetary Sciences, M.I.T., Cambridge, Massachusetts.

Seismic data from the Apollo Passive Seismic Network stations are analyzed to determine the velocity structure and to infer the composition and physical properties of the lunar interior. Data from artificial impacts (S-IVB and LM ascent stage) cover a distance range of 70-1700 km. Travel times and amplitudes, as well as theoretical seismograms, are used to derive a velocity model for the outer 150 km of the Moon. The P wave velocity model, shown in Figure 1, confirms our earlier report of a lunar crust in the eastern part of Oceanus Procellarum.

The crust is about 60 km thick and may consist of two layers in the mare regions. The possible values for the P-wave velocity in the uppermost mantle are between 7.7 km/sec and 9.0 km/sec. The 9 km/sec velocity cannot extend below a depth of about 100 km and must decrease below this depth. A detailed analysis of Apollo 17 data may resolve which model is appropriate. The elastic properties of the deep interior can be inferred from the seismograms of natural events (meteoroid impacts and moonquakes) occurring at great distances. There is an increase in attenuation and a possible decrease of velocity at depths below about 1000 km (Latham et al., 1973).

The composition of the crust can be inferred from the velocity model combined with laboratory measurements of velocities in lunar and terrestrial materials. As shown in Figure 1, these comparisons suggest that the uppermost layer is primarily basaltic. The second layer (25-60 km) has velocities which agree with those of aluminous basalts and anorthositic gabbros returned from the lunar highlands. If we adopt the 7.7 km/sec velocity, the upper mantle probably consists of a pyroxene-rich rock. The higher velocity (9 km/sec) model could imply a garnet-rich mineralogy resulting from the breakdown of plagioclase-rich rocks.

The physical properties and composition of the deep interior are constrained by considerations of thermal evolution, mean density and moment of inertia. Temperature models are calculated to satisfy the volcanism early in lunar history, the bounds on temperature from electrical conductivity, and present-day heat flow. The theoretical results predict a "hot" lunar interior with possible partial melting below 800 km depth, consistent with deep seismic results and moment of inertia requirements. From the mean density and moment of inertia, the presence of a low-density crust suggests that the lunar mantle may be inhomogeneous, with a density reversal at some depth.

Latham, G., et al., Lunar Tectonism and Interior. In "Lunar Science IV." Ed. J. W. Chamberlain and C. Watkins.

Todd, T., Wang, H., Richter, D. and Simmons, G. Unique Characterization of Lunar Samples by Physical Properties.

In "Lunar Science IV.", Ed. J. W. Chamberlain and C. Watkins.

LUNAR STRUCTURE

Toksöz, M.N., et al

FIGURE 1.

Comparison between the compressional velocity profile for the lunar crust and upper mantle derived from seismic measurements, and the velocities of several types of lunar and terrestrial rocks. The velocity model is shown by a heavy line (or dashed heavy-line where the model is uncertain). The lunar basalts for which velocities have been measured include samples from different sites. The region 2 ("Anorthositic gabbro") are bounded by Apollo 16 aluminous rocks (68415 at higher end and 62295 and 65015 at lower end and are from Todd et al (1973). Pyroxenites cover a wide range of composition. The garnet field is an average value for high-pressure phases of anorthite-rich rocks.

LUNAR STRUCTURE

Toksöz, M. N., et al

