THE MOON'S INTERNAL STRUCTURE AND ITS COMPOSITIONAL AND SEISMIC IMPLICATIONS; A.B. Binder and J. Voss, Institut für Geophysik, Neue Universität, D-2300 Kiel, W-Germany

A series of internal structure models for a laterally homogeneous moon have been calculated using the following boundary conditions: The moon has a low density crust of 60 km, 70 km, or 80 km thickness. The crust consists of an outer brecciated 10 km thick zone, the mean density of which (at zero pressure and zero temperature) is 2.6 g/cm^3; the lower part of the crust has an average density of 2.9 g/cm^3, as is consistent with its known petrology. The upper mantle, which, on the basis of petrological models of the source material of the mare basalt magmas, is an olivine rich peridotite with Mg' = 70 (1), has a zero pressure-zero temperature density of 3.47 g/cm^3 and reaches a depth of 200 km in most of the models and 300 km in certain limiting cases. The depth of the lower mantle is constrained by the assumption that any lunar core has a radius of less than 350 km in accordance with seismic (2) and magnetic (3) data. The density of the core lies between 4.6 g/cm^3 and 7.7 g/cm^3 (densities for pure FeS and pure Fe); the density of the lower mantle, i.e. the layer between 200 (300) km and the core boundary, is a variable parameter because there are only few constraints on its composition.

From the zero pressure-zero temperature densities, actual densities have been calculated using maximum and minimum temperature profiles taken from (4). These profiles match the boundary condition that the moon is currently at or near the solidus at depths below 800 - 1000 km and are taken from thermal history models which successfully account for the mare basalt epoch between 3 and 4 b.y. ago.

Calculations have been made by numerically solving the equation

$$\frac{d\rho}{dr} = -\rho(g\rho/k + a\frac{dT}{dr})$$

where	$\rho = \rho(p,T)$	density
	r	radius
	$g = g(r)$	gravity
	$T = T(r)$	temperature
	$k = k_o + k_T T + k_p p$	bulk modulus
	$a = a_o + a_T T + a_p p$	coefficient of thermal expansion
	$p = p(r)$	pressure

and $k_o = 1.28\text{x}10^{12}$, $k_T = -1.6\text{x}10^{8}$, $k_p = 5.2$,

$a_o = 2.7\text{x}10^{-5}$, $a_T = 1.6\text{x}10^{-8}$, $a_p = -1.3\text{x}10^{-16}$

as derived in part from the data of Skinner (5) on olivine.

Throughout the calculations the approximation has been made that the density varies linearly with depth within 2 km intervals (the integration step size), the gradient being determined by iterations.

The models are parameterized in terms of the above 3 crustal models, the variable density of the lower mantle and the size and the density of the core. All valid models meet the constraint of the total lunar mass and the normalized moment of interia of 0.392 $\pm$ .002 (6).

While there are models without cores which satisfy all the boundary conditions, those models with small cores of 200 - 300 km radius seem to be more realistic because they do not fall too close to the limiting values of the boundary conditions as given by their uncertainties.

Due to the strong temperature dependence of the density compared to the influence of the pressure, the lower mantle must be more Fe-rich than previously thought. The results indicate that Mg' of the lower mantle is approximately 75 in contrast to value of about 90 as derived by Binder (7) based on models of a fully differentiated moon. This value of Mg' provides a new and important constraint on the bulk composition of the moon.

Based on the petrological constraints of the upper mantle and the new Mg' value of the lower mantle the entire mantle should have a nearly constant P-wave velocity of 7.6 $\pm$ .2 km/s for all depths below the crust-mantle-boundary (neglecting possible effects of melting at depths below 1000 km). Goins et al. (8) get a constant velocity of 7.5 km/s below 500 km, but the current seismic models have a velocity of 8.1 km/s at the crust -mantle-boundary. This high velocity is questionable because it its based on single points on the travel time curve from the artificial impacts. Also, according to Nakamura et al. (9) there exist lateral heterogeneities in the upper mantle. They found apparent P-wave velocities ranging from 6.3 to 9.2 km/s. Their data have an average velocity of 7.7 $\pm$ .3 km/s. Therefore an upper mantle velocity of 7.6 km/s, as derived in this paper, is consistent with seismic interpretations.

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