Inversion of Geodetic Data and Core Sizes of the Moon for the Bulk Composition

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Constraints on the lunar core sizes come from the moment of inertia of the Moon, lunar laser ranging data, magnetic induction studies, and the abundance of siderophile elements in the mare basalts [1]. We jointly invert mean mass and mean moment of inertia and core sizes of the Moon for the lunar mantle composition using a Monte Carlo method. The general methodology is to combine geophysical and geochemical constraints and thermodynamic approach, and to develop, on this joint basis, the self-consistent model of Moon, accounting for its bulk chemical composition and internal structure. The mass and moment-of-inertia factor and a hypothesis of chemical differentiation of the Moon as a result of partial melting of initially homogeneous material (hypothetical magma ocean) are used to model the internal structure of the Moon. The chemical composition of the silicate Moon was modeled within the system CaO-FeO-MgO-Al_2O_3-SiO_2. For the computation of the phase diagram for a given chemical composition, we have used a method of minimization of the total Gibbs free energy combined with a Mie-Grüneisen equation of state and self-consistent thermodynamic data for minerals and solid solutions [2]. In this study, we consider models of internal structure of the Moon with five layers including a crust, a three-layer silicate mantle and a Fe–10 wt% S-core (ρ=5.7 g cm^{-3}), and discuss relationships between bulk composition of the silicate Moon and radius of a core. A law of temperature distribution in the lunar mantle has been adopted from [3].

Geochemical models of Ringwood, Taylor, O'Neill and others [2] have been examined and the ranges of chemical composition, mineralogy, velocities and density in the upper, middle and lower mantle as well as core sizes were determined for every computing model. The results of our inversion procedure allow us to establish the relationships between the bulk composition and core sizes. The probable empirical relationships between the lunar core radius R (km) and bulk concentrations of major oxides (wt.%) are proposed:

$$0.67*C(Al_2O_3)+0.33*C(FeO)=10.2-0.01*R,$$
$$MG\# = 77.44 + 0.02 * R,$$
$$C(MgO)=26.7+0.027*R,$$

where linear functions are found by the inversion of geodetic data and core sizes of the Moon. The basic conclusion arising from this study is that bulk lunar composition may be roughly searched out from the geophysically estimated values of the core radii. The distributions of the seismic velocities for the investigated geochemical models are discussing.

References

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[2] O.L. Kuskov, V.A. Kronrod, *Phys. Earth Planet. Inter.* **107,** 285 (1998)
[3] O.L. Kuskov, V.A. Kronrod, *Izv. Phys. Solid Earth*. **45**, 753 (2009)