Estimation of Moho depth under lunar basins by using only the GRAIL gravity data

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In order to unravel the formation of solar-system, the subsurface structure of planets and moons will be a key to constrain early differentiation and subsequent thermal evolution. In particular, lunar crustal thickness is of importance for understanding the volume of the ancient magma ocean. Conventionally planetary crustal thickness is estimated by analyzing gravity anomaly data derived from tracking data of spacecrafts using downward continuation filter. In this method, the relief of crust-mantle interface (Moho) are calculated as a variation of surface density anomalies under the condition that a mean crustal thickness or crustal thickness at a specific location has been already known from seismic observation. In this study, however, we demonstrate that the calculation is theoretically incorrect in the point that the Moho relief is imposed on the surface density at certain depth. Downward continuation filter is mathematical trick to stabilize the previous calculation, but it indeed violating gravity theory.

In this study, we show a new method which doesn't require ad hoc assumptions of crustal thickness nor downward continuation filter, but assumes the simple shape of Moho uplift. Under the assumption that the Moho is uplifted like an axisymmetric cylinder beneath Crisium basins , the observed Bouguer gravity anomalies can be expanded in the Bessel-Fourier coefficients . Then we find the best fit parameters such as radius, height and depth of cylinder. Thus, the depth of surrounding crust is estimated to be 37.9±7.7 km. Our estimate is consistent with that of the analysis result of moonquake data measured at Apollo 12 & 14 landing sites. This result indicates that the new method can estimate crustal thicknessby gravity data alone and independently from seismic data. Here we assumed a simple morphology of mass anomalies beneath Crisium basin, however, the top surface of the cylinder as well as surrounding Moho boundary shall be laterally variable. In further research we evaluate an influence of the shape, crustal flexure, and other effects.

Keywords: moon, crust, gravity, GRAIL, Moholovicic discontinuity

