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Comparative study of compensation mechanism of lunar impact basins from new gravity field model of SELENE (Kaguya)

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The gravity field is a fundamental physical quantity for the study of the internal structure and the evolution of planetary bodies. The most significant problem of the previous lunar gravity models, however, is the lack of direct observations of the far side gravity signals [1]. We then developed a satellite-to-satellite Doppler tracking sub-system for SELENE [2]. In this study, we adopt our new gravity field model with nearly full coverage of the lunar far side to discuss dichotomy of the lunar basins. Because all the nearside impact basins are filled with extensive mare basalt deposits, it is difficult to estimate the subsurface structures, such as uplift of the Moho surface, from gravity measurements. In contrast, far-side impact basins have much less or no mare basalt coverage. This may allow us to investigate the internal structure underneath impact basins. Such knowledge will be important in understanding the response of a solid planetary body to large meteoritic impacts and also the thermal state of the Moon during the late heavy bombardment period.

There are distinctive differences between the anomalies of the near side principal mascons and the far side basins. As shown previously [1, 3], the near side principal mascons have sharp shoulders with a gravity plateau and a weakly negative gravity anomaly in the surroundings. In contrast, the far side basins are characterized by concentric rings of positive and negative anomalies. The circular gravity highs agree well with the topographic rims of the basins revealed by SELENE topography model STM-359_grid-02 [4]. In our gravity model, Orientale, Mendel-Rydberg, Lorentz, and Humboldtianum show more affinity with the far side basins than the near side principal mascons [5]. Korolev, Mendeleev, Planck, and Lorentz basins have sharp central peaks of which magnitude in free-air anomalies is almost equivalent to the one in Bouguer anomalies. On the other hand, Orientale, Mendel-Rydberg, Humboldtianum, Moscoviense, and Freundlich-Sharonov basins have a broad peak of which magnitude in free-air anomalies is 20 to 60 % smaller than the one in Bouguer anomalies. We call the former basins Type I and the latter Type II.

The central gravity high of Type I basins in Bouguer anomalies suggests the existence of excess mass below the center. Because mare fill is absent from Type I basins, the central gravity high is most likely a manifestation of mantle uplift beneath the basin. The peak height of positive Bouguer anomalies of Type II ranges from 400 to 900 mGal in comparison to those in free-air anomalies from 250 to 500 mGal. This difference can be attributed to local compensation at the center of the Type II basins. We propose a brittle deformation resulting from a load of uplifted mantle. Little relation between the class and formation age is found. On the other hand, there are fewer large lunar basins on the far side. It is unlikely that large impacts concentrated on one side of the Moon and smaller impacts on the other side, as crater diameter depends mostly on impacting energy and momentum, not the properties of the target [6]. A plausible hypothesis is that the primary mascon basins on the near side have deformed more after their initial formation.

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