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The First Global Topography and Gravimetry of the Moon by KAGUYA

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Abstract

We present results of the first global topography and gravity measurement of the Moon by Japanese lunar explorer KAGUYA (SELENE), which was launched successfully on September 14th, 2007 by JAXA and stopped its operation on June 10th, 2009. KAGUYA obtained the first global topography of the Moon by a laser altimeter (LALT) with the range accuracy of 1 m, and accurate lunar farside gravity field by using two sub-satellites, Rstar (OKINA) and Vstar (OUNA). Some important suggestions concerning the internal structure of the Moon are derived, for example, degree of the elastic support of the lunar lithosphere, lunar Moho depth, etc, by the analysis of new lunar gravity and topography data.

1. KAGUYA Gravimetry

The gravity field, which is obtained by radio tracking of spacecraft, is a fundamental quantity for the study of the internal structure and the evolution of the Moon. However, the previous lunar gravity models are in lack of direct observations of the farside gravity. Synchronous rotation of the Moon with its orbit inhibits a direct link between a ground tracking station and a lunar-orbiting spacecraft over the farside. Using 4-way Doppler tracking with relay satellite OKINA, KAGUYA obtained the first precise gravity field of the lunar far-side [1]. Multi-frequency differential VLBI observation using subsatellites OKINA and OUNA improved the accuracy of gravity, through precise determination of OKINA's orbit. Current gravity field model SGM100h has much less error on the farside in comparison with previous models. The gravity field will be improved using differential VLBI data between OKINA and OUNA.

2. KAGUYA Topography

Laser altimeter (LALT) on board KAGUYA obtained the first precise global topography of the Moon with range accuracy of 5m [2]. Range data exceeded 20 million by the end of the mission. In the polar regions where laser altimeter on board CLEMENTINE did not observe, LALT clarified topographic features including permanently shadowed areas. Distribution of solar illumination rates was also estimated at elevated areas [3]. The amplitude of the power spectrum of topography spherical harmonics is larger than that of the previous model at $L>30$ [2].

3. Results and Implications

3.1 Gravity / Topography Correlation

We have better correlation of spherical harmonics coefficients between gravity and topography than the previous model [1]. Gravity signatures of far-side impact basins are mostly explained by topography except for the central high. Extended density anomalies such as "mascons" are not observed in the farside, suggesting the difference of thermal condition between the nearside and the farside. Probably the farside interior have cooled more rapidly than the nearside interior.

3.2 Lunar Crustal Thickness

Combined with topography data, we have estimated Bouguer anomaly and the crustal thickness variation of the Moon (Figure 1) [4]. The region with the thinnest crust is Mare Moscoviense in the far side. Bouguer anomaly does not change largely both within South Pole-Aitken basin (SPA) and within far-side highland terrain (FHT). This would imply relatively smooth crust-mantle boundary there. SPA is also characterized by the admittance spectra. Although the crustal thickness of SPA is much thinner than that FHT (Figure 2), the elastic thicknesses of both zones are not so different on the basis of the admittance. SPA area would be elastically supported by a part of upper mantle.

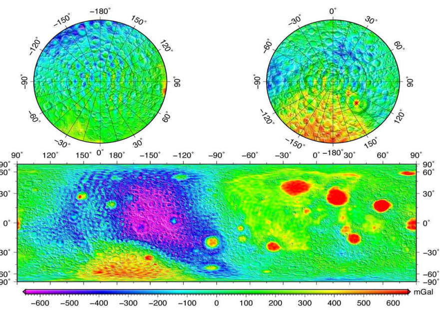

Figure 1: Global Bouguer gravity map of the Moon obtained by KAGUYA. It is based on the lunar gravity model SGM100h [5].

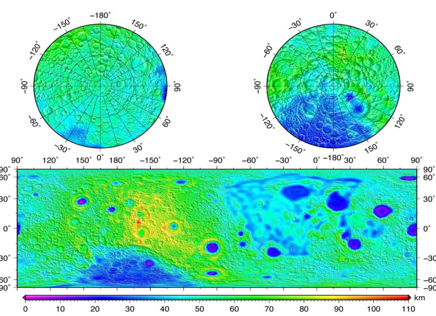

Figure 2: Global crustal thickness map of the Moon obtained by KAGUYA [4].

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