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Shape and Structure of the Lunar South Pole-Aitken Basin from KAGUYA Gravity/Topography

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The South Pole-Aitken (SPA) basin is the largest (2500km in diameter) and the deepest impact basin in the solar system. Although the SPA basin is large enough to have excavated the lunar crust, previous remote-sensing observations showed that the SPA floor is mainly occupied by materials in lower crust as well as impact melt/mare basalt. Previous analysis of gravity/ topography data also suggested the existence of lower crust at the SPA floor.
Using topography, Fe and Th abundance data, Garrick-Bethell and Zuber (2009) (GZ) stated that the SPA basin is characterized by an ellipse with axes 2400 by 2050 km with 53.2S - 191.8E center. They advocated that the basin was formed by an oblique impact. However, the lack of accurate far-side gravity data and topography data around the south pole region prevents quantitative discussion on the morphology and the interior structure of the SPA basin. Here, we analyze the structure of the SPA basin using the first precise global lunar gravity and topography data obtained by Japanese lunar explorer KAGUYA (SELENE).

KAGUYA was launched successfully on September 14th, 2007 by JAXA and ended its operation on June 10th, 2009. KAGUYA takes polar orbits and obtained global topography and gravity of the Moon. KAGUYA has a laser altimeter (LALT), which measures the distance between the satellite and the lunar surface. LALT produced global topography of the moon.
KAGUYA obtained accurate lunar farside gravity for the first time, using two small subsatellites, Rstar (OKINA) and Vstar (OUNA). We tracked the three satellites by new methods: 4-way Doppler tracking between the main satellite and Rstar for the farside gravity and multi-frequency differential VLBI tracking between Rstar and Vstar. The tracking data of KAGUYA over one year together with pre-Kaguya tracking data are used to create a spherical harmonics model of degree and order 100, SGM100h (SELENE Gravity Model). The large gravity error in the far-side in previous models is reduced in the new SELENE gravity model.
From topography and (free-air) gravity data, using crustal density 2800, mantle density 3360 kg/ $m^3$and assuming a uniform crust, Bouguer gravity anomaly, Moho depth, and crustal thickness are obtained. The crustal thickness is constrained from the condition that the minimum thickness is not negative.

In the cross section of KAGUYA topography across SPA, although the depression along the long axis is affected by a couple of large craters to the north, the overall depressed extent is larger along the long axis as was stated by GZ. Moho at the central region of SPA is as shallow as 30 km, whereas Moho depth just outside SPA is 50 ? 70 km. Crustal thickness at the SPA central region is as thick as 25km. The lower crust should have been exposed but significant exposure of mantle material is doubtful. The extent of shallow Moho region is shorter along the short axis of previous model. However, the central region with the shallowest Moho (the thinnest crust) is rather circular.
The Multiband Imager on board KAGUYA, with a high spatial resolution of optimized spectral

coverage, showed global distribution of (upper) lunar crust of high plagioclase abundance primarily using data of crater central peaks. Their results show that Leibnitz S and Poincare craters in the northern part of SPA have nearly pure plagioclase exposure. Plagioclase-rich crust should exist beneath some parts of SPA. Also the presence of ultramafic impact melt sheet is suggested from KAGUYA Spectral Profiler data.

We also analyzed the interior structure of impact structures in and around SPA. There is a distinct gravity anomaly and Moho uplift beneath Apollo. Poincare also show gravity anomaly/Moho uplift. Just outside SPA, obscure ring structure Amundsen-Ganswindt has distinct Moho uplift comparable that beneath Schroedinger, suggesting buried impact. Smaller basins (< 200km) shows little gravity anomaly.

Keywords: South Pole Aitken Basin, Kaguya, lunar gravity, crustal thickness, impact,
interiror structure of the Moon