LUNAR SOUTH POLE-AITKEN BASIN FROM KAGUYA(SELENE) GRAVITY/TOPOGRAPHY.

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KAGUYA Gravity and Topography Data: KAGUYA (SELENE) was launched on September 14th, 2007 and continued its operation by June 11th, 2009. KAGUYA had two subsatellites (OKINA and OUNA) for gravity measurements. Using 4-way Doppler tracking with relay satellite OKINA, KAGUYA obtained the first precise gravity field of the lunar farside [1]. Multi-frequency differential VLBI observation using OKINA and OUNA improved the accuracy of gravity. Using one-year tracking data, lunar gravity field model SGM100h was obtained [2] and the model was refined into SGM100i taking into account VLBI data [3]. KAGUYA has a laser altimeter (LALT) which measures the distance between the satellite and the lunar surface with accuracy of 1 m [4].

Assuming crustal density 2800 kg/m^3, mantle density 3360 kg/m^3, and mare basalt density 3200 kg/m^3 and assuming a uniform crust, Bouguer gravity anomaly, Moho depth, and crustal thickness are obtained [5]. The crustal thickness was constrained assuming that the minimum thickness is not negative. Here, we analyze the structure of South Pole-Aitken using the first precise global lunar gravity and topography data obtained KAGUYA (SELENE) mission.

South Pole Aitken Basin: The South Pole-Aitken basin (here after SPA) is the largest (2500km), deepest and presumably oldest impact basin in the solar system. It has degraded morphology and abundant superimposed craters. On the basis of topography, Fe and Th abundance data, Garrick-Bethell and Zuber (2009) (GZ09) [6] showed that the SPA is characterized by an ellipse with axes 2400 by 2050 km with the center at 53S - 191E. More precise topography and interior information from gravity are necessary to decipher the structure of large basin like SPA.

From the topography and the crustal thickness by KAGUYA, the direction of an ellipse denoting the depression is similar to that of GZ09. The region with the thinnest crust is offset southward from the center of SPA. In Fig.1, Moho depth at the central region of SPA is around 30km (25km in crustal thickness) and shallower to the southward. This may be explained by the oblique impact hypothesis advocated by GZ09.

Our crustal thickness is affected by the assumed anorthosite crustal density 2800 kg/m^3. KAGUYA MI showed evidence of anorthosite in SPA [7]. But spectral data of central peaks of craters inside SPA show ultramafic assemblage dominated by Magnesium rich orthopyroxene, suggesting the presence impact melt sheet [8]. This is compatible with previous remote-sensing data [9-10]. Then, higher crustal density would result in larger crustal thickness. The presence of lower crust in SPA was also discussed by previous gravity analysis [11-12].

Small basins in and around SPA: Since Bouguer anomaly is relatively flat in SPA as well as in the farside highland, surface morphologies could be supported by elastically in SPA. However, there are overprinted small impact basins with gravity anomaly. We analyzed interior structure of small basins in and around SPA (Table). We interpret positive gravity anomaly at the basin corresponds to Moho uplift.

There is distinct gravity anomaly and a Moho uplift beneath Apollo. Just around the rim of SPA, obscure circular structure Amundsen-Ganswindt has a distinct Moho uplift, suggesting a buried impact structure. A distinct Moho uplift beneath Schrödinger corresponds to the presence of olivine at the central peak rings there [13]. In comparison between adjacent Poincaré and Planck, older, less distinct Poincaré shows stronger gravity anomaly/Moho uplift. The observed anomaly corresponds to Type 2 like anomaly [1], where a significant uplift at the center is probably due to overcompensation at the impact. On the other hand, basin structures in the central SPA show little gravity anomaly. Although it might be caused by lower resolution, there are several possibilities such as less density difference between crust and mantle and rapid relaxation of an uplift.

Improvement of SPA gravity: We use localized representation of gravity potential according to the Han (2008) [14] where Slepian functions were used to estimate the gravity field over certain areas of the Moon. We express the gravitational potential in these localized functions in a resolution equivalent to degree and order 150 in spherical harmonics. We include data in a spherical cap area with a radius of 40 degree from the SPA center. This area is fully covered by 4-way Doppler tracking of KAGUYA. We obtained gravity adjustment about -70 to 50mGal in preliminary analysis [15]. The improved gravity field would supply better data of crustal thickness with slightly higher resolutions.

References: [1] Namiki, N. et al. (2009) Science, 323, 900, [2] Matsumoto, K. et al. (2010) JGR 115, E06007 [3] Goossens, S. et al. (2010), J. Geodesy, in press. [4] Araki, H. et al., (2009) Science 323, 897, [5] Ishihara, Y. et al. (2009) GRL, 36, L19202, [6] Garrick-Bethell and Zuber (2009) Icarus 204, 399, [7] Ohtake, M. et al. (2009) Nature 461, 237. [8] Nakamura, R. et al. (2009) GRL 36, L22202 [9] Head, J. W. et al. (1993) JGR, 98, 17149. [10] Pieters, C. M. et al. (2001) JGR, 106, 28001. [11] Wieczorek, M. A., Phillips, R. J. (1999) Icarus 139, 246. [12] Wieczorek, M. A., et al. (2006) In The New Views of the Moon, pp. 221-364. [13] Yamamoto, S. et al. (2010) Nature Geoscience 3, 533, [14] Han, S.-C. (2008) JGR 113, E11012, [15] Goossens, S. et al. (2011) manuscript.

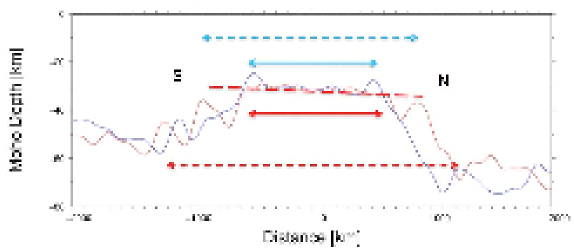

Figure 1 Cross section of Moho depth of SPA.. Red curve and lines correspond to the long axis of ellipse by GZ09. Blue curve and lines correspond to the short axis by GZ09.

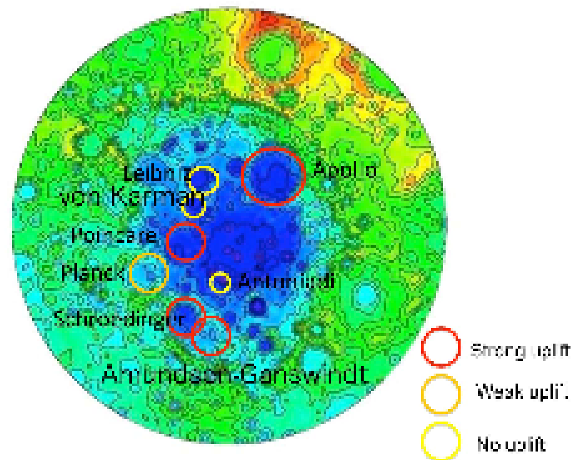

Figure. 2 Impact basins in SPA investigated here.

Table Impact basins within and around SPA.

			Diameter [km]	Clarity	Mare	Moho Uplift	Crustal Thickness [km]	Age
Apollo	36.1S	151.8W	538	Y	Y	Y	7	Pre-Nec(9)
Schrödinger	75S	132.4E	312	Y	Y	Y	24	Imbrian(12)
Amundsen-Ganswindt	81S	120E	335	N	N	Y	26	Pre-Nec(7)
Planck	57.9S	136.8E	314	Y	N	Maybe	35	Pre-Nec(7)
Poincaré	56.7S	163.6E	319	Y	Y	Y	16	Pre-Nec(4)
Von Kármán	44.8S	175.9E	180	Y	Y	N	23	Pre-Nec
Leibnitz	38.3S	179.2E	245	Y	Y	N	28	Pre-Nec
Antoniadi	69.7S	172W	143	Y	Y	N	27	Imbrian(12)