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Estimation of the lunar surface permittivity based on Kaguya radar sounder and imager observations

Ken Ishiyama[1*], Atsushi Kumamoto[1], Takayuki Ono[1], Naoki Terada[1], Yuto Katoh[1], Yasushi Yamaguchi[2], Shoko Oshigami[2]

[1]Tohoku University, [2]Nagoya University

For the discussions on the lunar volcanic history, it is important to understand the composition, age, spatial extent, and the amounts of accumulation of the lava flow. Previous studies based on the spectral observation and the crater chronology suggested that the basalt of the lunar mare surface was formed by the deposition of the lava erupted several times (Heather et al., 2002; Hiesinger et al., 2003). Lunar Radar Sounder (LRS) aboard the Kaguya spacecraft succeeded in identifying echoes reflected from the paleoregolith which is at the interface of lava layers (Ono et al., 2009). By assuming the depth of subsurface layers as the thickness of the basalt at the lunar surface, we can obtain the amount of the accumulated basalt in the wide spatial region covered by the LRS observations. However, for the purpose of the estimation of the thickness of basalt from LRS observations, we need to know the electric permittivity of the basalt. In the previous studies, the typical permittivity was estimated to be in the range from 4 to 11 based on lunar rock samples [e.g., Olhoeft 1975]. Although this assumption is acceptable for the rough estimation, we need the accurate value of the permittivity of the basalt in each area on the lunar surface for the accurate estimation of the thickness of the basalt.

In this study, we estimated the accurate permittivity of upper basalt from observations of LRS, Multi-band Imager (MI; Ohtake et al., 2008), and Terrain Camera (TC; Haruyama et al., 2006). We focused on the craters (Bessel A, Bessel D) in Mare Serenitatis. We defined the permittivity of basalt around the crater as eps_1. The analysis method was as follows. First, we identified the boundary of the layers exposed on the inside wall of the crater based on the spectral images observed by MI. Next, we obtained the thickness T of the basalt exposed on the inner crater wall from the depth of the identified boundary by using the digital elevation model (DEM) based on TC. Finally, we calculated the permittivity eps_1 from the identified thickness T, the apparent depth D measured by LRS, and the permittivity of vacuum eps_0. However, we need to use assumptions of the crater formation model to calculate the thickness T. Because craters were created by the impact of meteors on the lunar surface, it should be considered that the boundaries between the subsurface layers were not simply exposed on the crater wall and are deformed by the shock wave generated when the meteor impacts. In this study, we assume some deformation models of the layers in order to estimate the permittivity eps_1 of the upper basalt layers.

We also compared the estimated dielectric constant with that of the rock samples collected by Apollo.

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