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Measurements of the density, permittivity, and crack distribution in basalt targets based on the impact experiment

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The many meteorites have impacted the lunar surface during ˜4.6 Ga, in which the crater terrain is formed. In lunar nearside, the lunar lava (basalt) covers the inside of the basins (mare region), formed by large meteorites. The Lunar radar sounder (LRS) onboard the Japanese lunar orbiter SELENE (KAGUYA) radiated the electromagnetic wave in the Moon and succeeded in detecting the lunar surface and subsurface reflectors in the mare region [Ono et al., 2009]. Using the LRS data, Ishiyama et al. [2013] estimated the bulk permittivity of the lunar uppermost basalt layer and suggested a high porosity (more than ˜20%) of mare basalts. This estimated porosity is higher than the porosity of the Apollo basalt samples, so that the impact-induced macro cracks, which are not included in the Apollo basalt samples, are probably introduced in the lunar uppermost basalt layer. However, we cannot evaluate the subsurface distribution of the impact-induced macro cracks and the effect of the cracks on the permittivity estimated from the LRS data. Therefore, we produce the artificial impact crater on the basalt target based on the impact experiment, and measure the density, permittivity, and crack distribution in the basalt target.

We performed the impact experiment by using the two-stage light-gas (hydrogen) gun at JAXA on December 2014. The spherical stainless projectiles (0.32 cm in diameter and 0.133 g in mass) were launched at the velocities of 3.5, 4.5, 5.5, 6.5 km/s to investigate the impact velocity dependency and impacted on the basalt targets of 20 cm$\times$20 cm$\times$10 cm. We repeated the impact experiment twice for each impact velocity in order to confirm the repeatability. Next, we drilled core samples (2.5 cm in diameter and 8-10 cm in length) from the basalt targets along a horizontal and depth directions in order to investigate the effect of anisotropic crack on the permittivity. This investigation gives us the opportunity of the verification based on the effective medium theory [e,g., Sihvola, 1988], which supposes the effect of anisotropic crack on the permittivity. Finally, we sliced the core sample each of ˜4 mm in thickness and polished the surface of sliced samples to measure permittivity and surface crack distribution.

We estimated the density of the sliced sample from the measurements of its mass and volume, and investigated the crack fraction by scanning the surface of the sliced thick sample. The permittivity of the sliced thick sample was measured at 5 MHz by using the permittivity measurement system (TOYO Technica Corporation: Type-1260 impedance analyzer and Type-12962A interface) for measuring the permittivity. In the presentation, we will report the initial analysis result of the sliced samples.

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