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Exploration of the lunar internal structure using a small-sized penetrator and its perspective

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Information about the lunar interior has been obtained by the seismic exploration through the Apollo mission, the gravimetric explorations of the Kaguya and GRAIL missions, and other geodetic observations such as the Lunar Laser Ranging (LLR). However, we have not sufficiently constrained the lunar deep mantle and the core from available geophysical data, and the material and temperature in the lunar deep region are still uncertain. In addition, we have some uncertainties even about lunar crustal thickness and structure. Clear detections of lunar seismic phases which pass through the lunar deep and crustal regions will be required to reveal the structures. The penetrator, a hard-landing probe with a high sensitive seismometer developed in the former LUNAR-A project, is a powerful tool to carry out new lunar seismic observation.

To demonstrate utility of the penetrator system for scientific observations, we proposed a mission plan, named APPROACH, in which one penetrator is loaded onto a small satellite launched by the 3rd Epsilon Launch Vehicle. In this proposal, we had some plans to perform scientific observations; those are determination of the lunar crustal thickness using travel time data from meteoroid impact events located by the ground observation of the impact flashes, current lunar seismic activities compared with that during the Apollo-era and the first heat flow measurement on the lunar highland. However, the proposal could not be accepted because the success rate of the observation with only one penetrator was insufficient for acceptance.

In this situation, we currently make a modification to the mission plan so as to load two small-sized penetrators onto the small satellite. We aim to reduce the size of the penetrator to two-thirds size keeping the already established high shock durability. In this presentation, we firstly report some plans to reduce size of the penetrator and the effect of the downsizing on scientific observations. Then, we describe scientific expectation from the seismic and heat-flow observation using the small-sized penetrator. Finally, we will discuss future plans to study the lunar origin and evolution by the lunar seismic observations using the penetrator system after the achievement of first observation by the system.

Keywords: Penetrator, Lunar intarnal exploration, Moonquake observation, Heat flow observation, Small-sized exploration satelite