Observing simulations of impact-induced moonquakes combined with the lunar impact flash observation data for future lunar seismic explorations

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Over the past 50 years, the lunar interior has been investigated by analyzing the Apollo lunar seismic data (e.g. [1]-[3]). However, currently proposed models of the internal structure are not in accordance with each other although each model can explain the Apollo seismic data. This means there still exists a large uncertainty in the lunar internal structure because the Apollo data does not have enough quality to determine the inner structure precisely. Since the internal structure is a significant factor to elucidate the origin of the Moon, it is essential to obtain new seismic data in order to improve our knowledge of the lunar internal structure.

In particular, the lunar crustal structure (e.g. elastic velocity, density, layer-thickness) is significant when discussing the thermal environment at the initial stage of the lunar formation. From the observation results of KAGUYA (SELENE), it is suggested that the lunar crust consists of very pure anorthosite, which means the refractory element Al concentrates within the crust (e.g. [4][5]). Since the bulk amount of refractory elements gives a strong constraint on the thermal condition of the lunar formation, revealing the lunar crustal structure will lead to better understanding of the history of the Moon.

When determining the lunar crustal structure, impact-induced seismic waves are usually used [6]. Generally, at least 3 seismic stations are required to determine seismic source locations. In the case of the Apollo, although 4 seismic stations were placed and made a network on the nearside of the Moon, it was difficult to determine the impact locations (seismic source locations) precisely due to uncertain arrival time readings and unknown origin times. In future seismic explorations, it is required to carry out seismic observations even at a single point since it is difficult to deploy multi-seismic stations at once. In this situation, the precise determination of origin times and impact locations will play an important role in order to improve the crustal structure. However, as described above, it is considered that a single seismic station is not adequate for the precise determination of origin times and impact locations. This is one of the serious problems when performing a future seismic exploration.

In order to overcome this problem, it has been proposed to apply ground observation data of lunar impact flashes to seismic observations on the Moon [7][8]. Since the basic recording system of the impact flash observation allows us to determine impact times and locations more precisely compared to seismological approaches, it will enable to realize seismic observation at single point. However, these fields of study (lunar impact flash and lunar seismology) have been carried out independently in the past. In this study,

we bring these two field together by performing observing simulations of impact-induced seismic waves by combining a seismological simulation with the lunar impact flash observation data as a first step for the consideration of a future seismic exploration.

In the presentation, we will report the simulation results of the lunar seismic observations and discuss the requirements for a future seismic instrument and landing site.

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キーワード：月、月震、将来探査、衝突、月面衝突閃光
Keywords: Moon, Moonquake, Future Exploration, Impact, Lunar Impact Flash

