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The Lunar Surface Gravimeter as a Lunar Seismometer: New Identification of Unlocated Deep Moonquakes

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The internal structure of the Moon is an essential piece of information to investigate its origin and evolution. The seismic analyses using the data from Apollo Passive Seismic Exploration (Apollo 11, 12, 14, 15, 16) are one of the most successful methods carried out to estimate the inner structure of the Moon. From the seismic analyses, it was found that the Moon is still seismically active and the Moon has layered structure with 40∼60 km crust with mantle below. However, because of the limitation of seismic network, only with 4 seismic stations all on the nearside, the experiment could not fully uncover the lunar interior, especially for the region deeper than 1000 km. This is still an important question of the lunar science and new data were desired. In our previous studies, we showed that the Lunar Surface Gravimeter on Apollo 17 can be used as a seismometer. We succeeded in relocating the known seismic event and improving its location by using the additional seismic data of the LSG. In this study, we attempted to locate deep moonquakes that could not be located with the previous data set by using the LSG data. Deep moonquakes are said to occur periodically, at certain seismic source or nests. It is known that seismic events of the same nest have almost identical waveforms at one station. This is the unique characteristic of deep moonquakes and classification by waveform cross-correlation is possible. In this way, more than 300 nests were identified. 106 of them provided sufficient data to locate their sources. Among the remaining unlocated deep moonquakes, 60 provided usable waveform data at more than one station. In this study we focused on these 60 nests and examined whether they are locatable by adding data of the LSG. First, we picked up data for seismic event whose LSG data were available. This leaves 40 nests to be examined with the additional data of LSG. We examined all the seismic events from the 40 nests and identified seismic events from 5 nests were detected by the LSG. These events were used for the source determination and we succeeded in locating 5 new seismic sources. Though their location error is large, it shows that the additional data of the LSG can be used in the source determination of the unlocated moonquakes. Among these unlocated moonquakes there is moonquakes that might be on the lunar farside. If we can detect new farside deep moonquakes we may extract new information of the lunar interior from them. In the 5 newly determined seismic sources, A284 were estimated to be on the farside and the estimated source is located at one of the most distant region from the observation network. The additional data of the LSG can be used to identify the previously unidentified seismic source and such source can provides us with new