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Seismological aim of broadband observation in the SELENE2 mission

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ELENE2 is the first mission that Japanese scientists plan to send one or two landers on the moon. We propose a broadband observation of moonquakes as a scientific device. We review seismological results from the Apollo missions and show importance of a broadband observation and its scientific targets.

In the 1970s, the Apollo 12, 14, 15 and 16 missions, made a seismic network of which shape is a triangle with one side about 1000 km in length, on the moon. Each station had a three-components long period seismometer and a one-component short period one. The observation lasted more than seven years until September 1977 when a stop command were sent to the moon, and it provided us with much information on lunar seismicity and internal structure down to 1000 km. Moonquakes observed by the Apollo mission are categorized as shallow moonquakes, deep moonquakes, meteorite impacts and thermal moonquakes. Deep moonquakes frequently occur at a depth from 800 to 1000 km and form clusters. Each cluster repeats with a period about 27 days. Shallow moonquakes are larger and seldom occur a few times per year; thermal moonquakes are very small and were observed near the stations.

Although the seismic observation of the Apollo missions much contributed to selenology, frequent deep moonquakes are small and marginally detectable. Hence a pickup time of P and S arrivals has an ambiguity about several seconds to tens. This means the deep structure more than 200 km in depth is obscure since it is mainly inferred from seismic wave arrivals of deep moonquakes observed in the Apollo missions. Precision in a pickup measurement depends on steepness of a wave front. To make a rise of a wave clear, a broadband observation of deep moonquakes is requested.

Because of the resource limitation of SELENE2, number of stations is limited to one or two. We, accordingly, prefer to focus on frequent deep moonquakes of which location is well known. We will observe them using a seismometer with broader frequency and wider dynamic ranges than those of the Apollo seismometers and try to obtain structure of the crust and upper mantle. If we have a large shallow moonquake or a large impact in the scheduled observation period, we will obtain good S/N ratio in observed waveform and can detect some depth phases that are informative on structural discontinuities. And we will also try to understand mechanism of deep moonquakes from broadband waveforms and try to detect the far side events. Deep moonquakes were detected only by Apollo's long period seismometer in PEAKED MODE that is very narrow band response and has higher sensitivity than that of the short period seismometer below 1 Hz. Corner frequency of such a small seismic event is expected to be much higher than 1 Hz. Thus a broadband waveform of a deep moonquake is very promising to determine its source time function that reflects physical property of the source. As for the determination of crustal thickness using receiver function method, a broadband waveform is a key to fine determination.