The characteristics of the seismometer on board the penetrator and the seismic observation

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In Japan, the hard landing probe penetrator is developed, which is a useful tool to develop the geophysical station on the region where is hard to visit, such as the moon and planet. At the Japanese LUNAR-A mission, two component seismometers are loaded on the penetrator, and after the deployment on the moon by the penetration, the moonquake observation by them had been planed to investigate the lunar interior.

In this presentation, the characteristics and specifications of this seismometer on board the penetrator, which is a short-period electromagnetic seismometer with velocity transducer, and the results of the seismic observations by it will be reported.

When the penetrator impacts to lunar regolith, about 6000˜8000G impacting shock is expected to be taken to the seismometers. The seismometer must have the impact durability to retain its characteristics after the penetration. In this study, we made the impacting test, which was made to provide the qualification test condition to the seismometers by using the penetrator and the facility of Sandia National Laboratory. The penetrator was projected by a Davis gun and penetrated into the target regolith of lunar stimulant with much severer conditions than those of the actual impact on the moon. We made the confirmation tests for the characteristics (resonant frequency and damping constant) and the dynamic response to the actual ground motion of this shock-induced seismometer on board the penetrator.

Because the seismometer is designed to have high sensitivity for very quiet environment on the moon, the observed waveforms usually contain large noisy signals on the earth. Therefore we selected the Inuyama Seismic Observatory of Nagaya University as the observation site. It is the quiet seismic observatory, where the level of seismological noise is very low; the level of micro tremor consists with maximum amplitude of some large deep moonquakes (1E-8-1E-9 m/sec in terms of the velocity of ground motion at a frequency of 1Hz).

After the deployment of the shock-induced penetrator, we obtained the calibration waveforms from the two components seismometers (the horizontal and the vertical) on board the penetrator by using a capability of the penetrator. From analysis of these waveforms, we found that two seismometers have preserved the required characteristics for moonquake observation after the impact shock.

Next, we have confirmed the dynamic responses to the micro ground motion of two seismometers. In the observation test, three types of reference seismometers were used. One is the penetrator seismometer which is not loaded into the penetrator and others are L-4 geophone (Mark Product) and Streckeisen STS-2 broadband seismometer.

Inside of the penetrator, two components seismometers are suspended by the gimbals mechanism to reorient them to the desired direction by two axes motors. The seismometers are sustained by friction wheels of the rotation mechanism and two opposing bearing of the gimbals mechanism. The seismometers may be affected by the elastic properties of the gimbals, especially of the friction wheels and of the bearing. Moreover, because two components seismometers are set near location in the gimbals, one seismometer may be affected by the other seismometer. In this study, from comparison of the observed signals by the seismometers on board the penetrator with those of references, we estimate these effects to the signals and will report this result.