Lunar active seismic profiler (LASP) for lunar polar exploration

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To explore ice deposits in the lunar polar regions, we have been designing and developing a lunar active seismic profiler (LASP) with active seismic source and receivers. The active source continuously generates vibration with wide frequency range. By stacking the continuous waveforms (chirp) recorded by seismometers, we improve signal-to-noise ratio of the signal. Thus, less-energy vibration with small-size seismic source could be utilized in our system. If both lander and rover have active source and seismic array, we can simultaneously conduct 3 different seismic surveys; (1) surface wave analysis, (2) seismic refraction analysis and (3) seismic reflection analysis.

To investigate the possibility of LASP to identify low-saturated ice deposits (0.5wt%), we first conducted laboratory measurements. In laboratory experiments, we measured P-wave and S-wave velocity of lunar regolith at various conditions and obtained the relationship between seismic velocity and ice saturation (0-1wt%). The results demonstrate that S-wave velocity increases ~15 m/s when ice saturation increases from 0 to 0.1wt%. To estimate 0.5w% saturated ice, therefore, we need to resolve ~50m/s velocity anomaly using our active seismic profiler.

We made source-receiver array system for field experiment and tried to identify optimum acquisition system and data processing method. To obtain stable dispersion curve from the short-offset data (~1m), we developed new analysis method (i.e., continuous wavelet transform MASW). By applying this method to the field data, we obtained S-wave velocity from surface to 1.5 m depth, in the accuracy of ~5 m/s. Therefore, using this system, we can resolve <0.1wt% ice distribution. Using our LASP system, we succeeded to estimate 3D shallow geological structure around Kyushu University. In addition to the surface wave analysis, we estimated P-wave velocity of shallow layer and deeper basement by applying seismic refraction analysis to the long-offset data (i.e., signal generated by rover is recorded by lander).

Keywords: Active seismic survey, Surface wave analysis, Relationship between seismic velocity and ice saturation, 3D seismic velocity, Lunar regolith

