Geophysical exploration in frontier environments using recent methods

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We show the recent progress of shallow geophysics in frontier environments, such as Moon and Mars. We have been designing and developing a lunar active seismic profiler (LASP) with active seismic source and receivers in order to investigate ice deposits in the lunar polar regions. The active source continuously generates vibration with wide frequency range. By stacking the continuous waveforms recorded by seismometers, we improve signal-to-noise ratio of the signal. Thus, less-energy vibration using small-size 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 (including reverse vertical seismic profiling). Recent laboratory and field experiments demonstrate that our LASP can detect less than 0.1 wt% ice saturation using active-source surface wave analysis.

Three-component seismometer was further deployed by InSight lander touched down on Mars. The seismometer within the InSight lander has recorded continuous ambient noise. We applied a polarization analysis of InSight seismic data to estimate temporal variation and frequency dependence of the Martian ambient noise field. The applied polarization analysis can extract the dominant back-azimuth and directional intensity of ambient noise. High-frequency (4–8 Hz) P-waves show a diurnal variation in the dominant back-azimuth that appears to be related to wind and direction of sunlight in a distant area. High-frequency Rayleigh waves (4–8 Hz) also show diurnal variation and a dominant back-azimuth related to wind direction in a nearby area.

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