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DYNAMIC CONE PENETRATION AS A SEISMIC SOURCE IN LUNAR HIGHLANDS REGOLITH SIMULANT.

Abstract

Penetration and seismic experiments are often proposed for space missions (e.g. InSight, Philae, Chandrayaan 3) and both methods were used by Apollo astronauts. These methods can be used to characterize the subsurface which is required for surveying, resource exploration, and construction. Active seismic methods are used to characterize subsurface properties of local areas in contrast to passive seismic methods that typically characterize large scale areas. Cone penetration can be divided in static and dynamic, where in the case of dynamic cone penetration test (DCPT), the probe is hammered into the ground as opposed to pushing it at a steady rate. DCPT can provide similar data to that of the regular cone penetration test (CPT), and it comes with the major advantage that it doesn't rely on a reactive force. In effect dynamic cone penetrometer (DCP) could be mounted even on a rover. Exploration Architecture Corp. (XArc), with their SurveyorBot rover project, proposed to use the DCP and active seismic methods in tandem. This work examines the feasibility of such an approach.

DCPs that are routinely used in civil engineering, geology, agriculture, and military are too large and heavy to be directly transferable to rovers. A bespoke Mini-DCP has been produced with 4 different cones (12.7, 20, 27.5 and 38 mm diameters) and with changeable hammer stroke energy, from 0.23 to 5.88 Joules, different Mini-DCP setups were used in the experiments. Mini-DCP hammering was used as a source for multichannel analysis of surface waves (MASW) seismic experiments. A cubic metre large compaction chamber was produced to control the density of engineering grade lunar highlands regolith simulant (LHS-1E).

A result of MASW experiments is a shear wave velocity versus depth profile. From the variables that influence the shear wave velocity, only the density of the regolith was changed between experiments. Shear wave velocity increases with density and depth. Additional variables like cone size and hammer stroke energy should not influence the shear wave velocity, but they affect the detectability of the seismic signal. In this work the highest quality seismic data were produced when the largest cone size was used in conjunction with the smallest hammer stroke energy.

The DCP can be used, not only to penetrate the regolith without a reactive force, but also as a source for active seismic experiments. The findings of the MASW and DCP experiments can be directly used when developing payloads for lunar active seismic experiments.