Using Real-time Drilling Data to Characterize water-ice on Moon. D. Joshi[1], A. Eustes[2], J. Rostami[3], C. Dreyer[4], Z. Zody[5], W. Liu[6]
[1,2,5]Petroleum Engineering, Colorado School of Mines, 1500 Illinois St, Golden, CO. 80401.
deepjoshi@mymail.mines.edu , aeustes@mymail.mines.edu, zzody@mymail.mines.edu
[3,6] Mining Engineering, Colorado School of Mines, 1500 Illinois St, Golden, CO. 80401. rostami@mymail.mines.edu, wenpengliu@mymail.mines.edu
[4] Center for Space Resources, Colorado School of Mines, 1500 Illinois St, Golden, CO. 80401. cdreyer@mines.edu

The recent push by NASA and the US government to increase sustainable human presence on Lunar surface heavily relies on the application of In-Situ Resource Utilization (ISRU) techniques. One of the most valued resources on the Moon is water. The water has application ranging from fuel or propellant production to human consumption. A hindrance to lunar mining has been that the uncertainty related to the assessment of the volume and characterization of water-ice. The orbital estimates of the quantity, distribution and composition of the water-ice varies widely based on the analysis of available information. Exploration drilling at target sites is critical to establishing the ground truth for planning the future extraction or mining activities.

The goal of the current study is to analyze the drilling systems developed by NASA and other agencies for extraterrestrial exploration, design a drilling rig to replicate the operations of these drilling units, and develop a pattern recognition algorithm that analyzes real-time high-frequency drilling data and estimates the subsurface geotechnical properties. This work is based on the analytical and data-driven models developed by the drilling industry to characterize subsurface formations based on drilling parameters. This work builds up on existing models to apply them to an auger based rotary drilling system. Figure 1 shows the drilling unit developed to conduct drilling tests.

Figure 1: Test drilling rig

This paper will discuss the results from the initial drilling tests, conducted on homogenous analog grout samples to replicate one of the expected lunar subsurface conditions. The high-frequency drilling data was filtered to remove the drilling noise and correlated to the lab tests to find distinct patterns of various drilling parameters related to strength of the media being drilled. Figure 2 shows the mechanical specific energy recorded through different boreholes in the first block. Just based on drilling data a layer of harder formation was detected and tracked across the borehole. Further analysis of the drilling data also revealed the problem with hole cleaning and removal of the cuttings. It showed that the drilling auger used in testing was inefficient in removing cuttings below 250 mm of drilling depth.

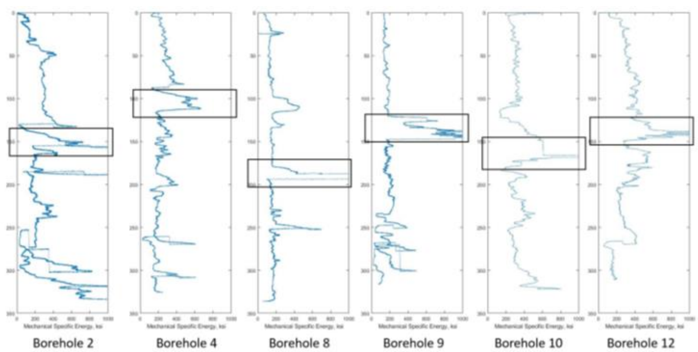

Figure 2: tracking mechanical specific energy across boreholes revealed a harder layer in the grout block and a cutting transport problem around 250 mm depth

The recorded high-frequency drilling data will be used to assess the relationships between various material properties and drilling parameters for real time assessment of geotechnical units being drilled. The pattern recognition algorithm being developed can enable cost-effective exploration of water-ice resources on Moon and Mars and real time generation of information on material strength. This is the key component for development of the ground profiles, and proper preparation of the exploitation plans.