OptiDrill: The next-generation instrumented drill.

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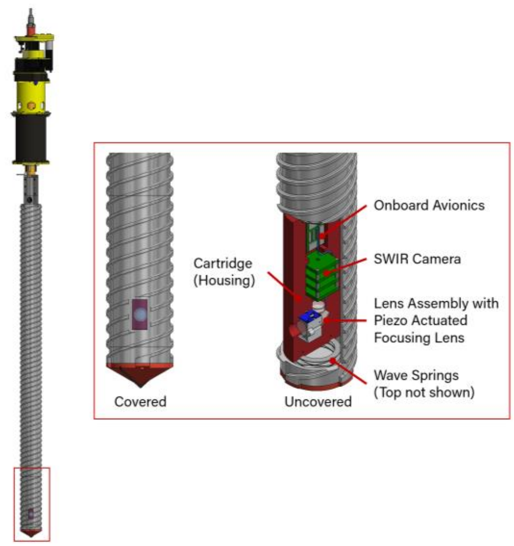
Introduction. Preserving unconsolidated regolith stratigraphy in samples and examining undisturbed grains is necessary for extraplanetary surface science to understand formation processes and characterize water content. Even using current-generation regolith-oriented coring drills, unconsolidated regolith stratigraphy can be destroyed in the process of extracting the core for study after drilling and water icy quickly sublimates once brought to the surface. In this technology development effort, OptiDrill, addresses the critical technology gap that exists for the study of undisturbed samples on other planetary surfaces.

Multispectral data from landed, orbital, or telescopic observations [1] have been used to map compositional variations of the Moon's surface materials. These observation and lunar meteorite studies shows that the Moon's surface materials vary both laterally and vertically in composition, age, and mode of emplacement. However, to determine the original environment that led to their formation and to understand the formation processes that produce the lateral and vertical variability it is necessary to conduct in-situ spatially-correlated mineralogy and microtexture identification.

In-situ direct measurements are also critical for the detection and quantification of water ice. Experiments and estimations have shown that significant water is lost to sublimation in the drilling process [2] conducted drilling experiments into frozen icy lunar regolith simulant samples with a drill under lunar vacuum and cryogenic conditions. They showed the average water lost in the process of drilling and bringing cuttings to the surface was 30% but varied between 22.7% and 46.8%. The major source of water loss was thought to be sublimation into vacuum.

Design. OptiDrill is a next-generation instrumented drill that enables the spatially-correlated mineralogy and microtexture identification within rocks and regolith. The 2022 ExoMars lander would have a drill embedded with the Mars Multispectral Imager for Subsurface Studies (Ma-Miss) which is a miniaturized infrared radiation (IR) spectrometer for borehole exploration [3]. This accomplishment is a foundational advancement for in-situ planetary investigations but places significant constraints (increased: footprint, shielding and heating needs, and complicity). The next logical step is to develop auger that contains the instruments.



OptiDrill's in-situ multispectral microscopic imager is contained within the augur and is suitable for a range of planetary surface explorations including the Moon, Mars, asteroids, or even icy worlds (**Error! Reference source not found.**). This instrument provides quantitative and qualitative mineralogical analysis and water content of rocks and regolith samples. The driving rational behind this work is to bring the instruments to the sample instead of the sample to the instruments, providing an otherwise unattainable spatially-correlated data sets of mineral and microtexture identification. The major components that allow OptiDrill to address the current technology gap are a drill that houses in the auger a small, high resolution camera and optical assembly.

Ongoing Work. Subsurface investigations are being performed with OptiDrill in the 0.95 to 1.75 µm spectral range with a spatial resolution of ~10nm – appropriate for identification and characterization of minerals and ice in the near surface regolith of the Moon. This high spatial resolution will enable identification of mineralogical composition at the scale of rock grains in-situ along the borehole wall. The imager also allows for determination of the porosity and the shape and spatial distribution of the mineral grain for a better understanding of the regolith/rock physical properties.

References:

[1] Belton, M. J. et al (1992) *Science*. [2] Formisano et al., (2019) *Planetary and Space Science.* [3] Coradini et al. (2001) *Advances in Space Research.*