

**REBELS: Rapidly Excavated Borehole for Exploring Lunar Subsurface.** K. Zacny, J. Palmowski, L. Stolov, K. Bywaters, Honeybee Robotics, 2408 Lincoln Ave, Altadena, CA 91001 ([kazacny@honeybeerobotics.com](mailto:kazacny@honeybeerobotics.com)).

**Introduction:** The depth of lunar subsurface exploration has been limited to 3 m: this is the depth of the three lunar cores captured by Apollo 15, 16, and 17. Soviet Luna 24 sample return mission drilled to 2 m, while Chang'e 5 to 1 m. Future missions such as PRIME1 and VIPER are limited to 1 m depth.

Understanding the stratigraphy on the 10 m scale in the mid-latitude and polar regions would significantly enhance our understanding of the gardening as well as volatile distribution.

**REBELS:** Rapidly Excavated Borehole for Exploring Lunar Subsurface (REBELS) is a Coiled Tubing drilling system designed for penetrating

- Near Infrared Spectrometer (NIR):
  - Volatiles, Mineralogy
- Neutron Spectrometer (NS):
  - Hydrogen (water)
- Temperature Sensor and Heater (TSH)
  - Temperature, Thermal conductivity → Heat flow
- Dielectric Spectroscopy Probe (DSP):
  - Electrical properties
- Camera:
  - Surface texture
- Drill telemetry
  - Subsurface strength, Water content (wt. %), Water-ice physical state

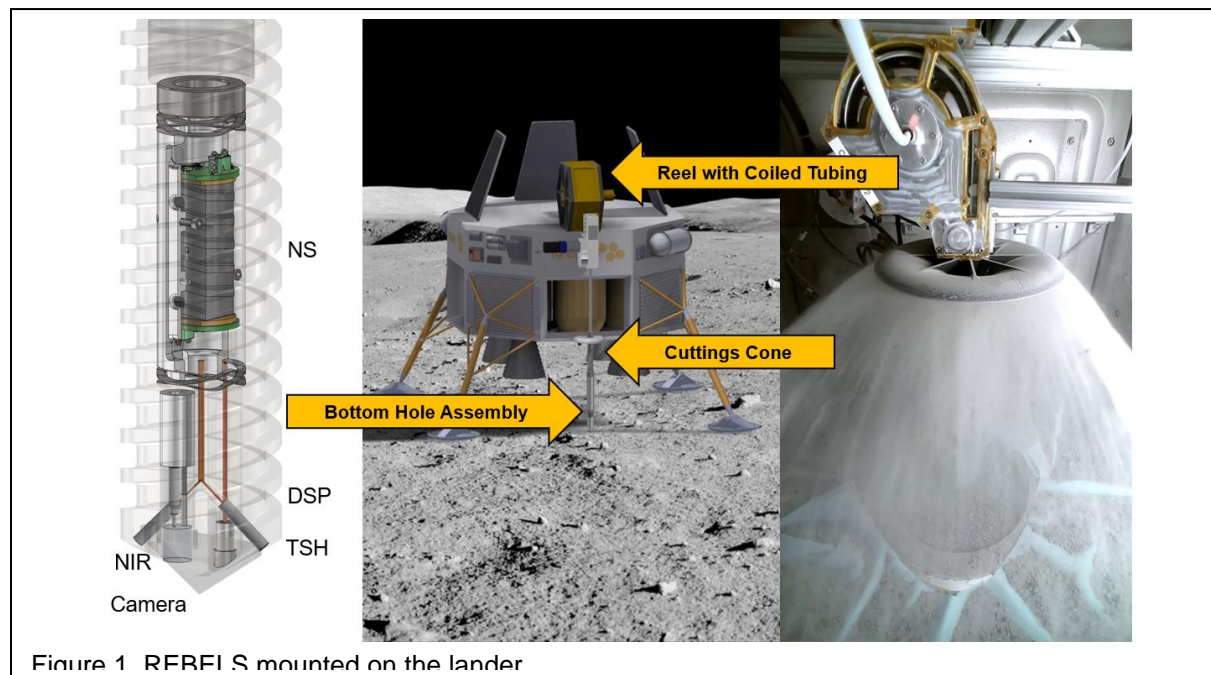


Figure 1 REBELS mounted on the lander

>10 m below the surface. It is based on Honeybee Robotics RedWater drill, currently under development for penetrating 25 m on Mars, LISTER – a 3 m pneumatic drill scheduled to fly to the Moon in 2023 (Mare Crisium), and 2025 (Shodinger basin), and SMART drill under development for the RESOURCE project.

REBELS coiled metal tubing is reeled out from a drum and re-formed into a straight tube. The end of the tube includes the Bottom Hole Assembly (BHA). The BHA consists of a Drilling Subsystem (motors, drill bit etc.) as well as a Sensing Subsystem with the following instruments:

The drill uses a mechanical drill bit to cut into the formation and compressed gas to blow the cuttings to the surface. The coiled tubing acts as a conduit for the wires, fiber optics and gas.

The main advantage of REBELS is to bring the instruments to the sample – i.e., all the instruments in the BHA can be activated real time and take subsurface data during drilling.

In addition, the cuttings being blow out of the hole can be analyzed real time and also collected for analysis by onboard instruments.

Various subsystems of REBELS are currently being developed to TRL ranging from 4 to 6.