Construction of human habitation facility on Mars using low-power low-mass autonomous robotic system.

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Abstract: Preparations for human landing on Mars involve many challenges and efforts to address the requirements for "living off the land" have been initiated in many ISRU related tasks and initiatives [1]. Critical to the ability of humans to operate on Mars upon landing is the availability of an established infrastructure that includes shelter (for radiation protection, sleeping/living quarters, etc.), storage with resources, and landing facility. This would require construction of the landing site(s) as well as the related facilities for which a key would be the fabrication basic blocks, i.e., bricks, to allow building the required structures. A percussive fabrication system that uses rectangular or square cross-section bits would allow producing such blocks [2, 3]. An example of a square cross-section bit that was used to demonstrate this capability is shown in Figure 1.

Figure 1: Square cross-section bit of a percussive drill.

The task of making brick shape cores would require methods of producing uniform length pieces, removing the cuttings during the process, extracting the pieces and handing them to a rover to perform construction. The task would involve autonomous construction of structures by a percussive brick producing system that would operate cooperatively with a robotic arm on a rover. The generated powdered cuttings would provide resource material to create mortar to glue the bricks and using heat, generated by solar energy, produce glassy material for sealing the structure walls for storage of water, fuels, or gases (oxygen, etc.). The boreholes produced by the system may be used as storage areas while the produced powder could be tested to support science investigations as well as analysis to determine issues that may affect human operation in the constructed site(s). The size of the produced bricks would be dictated by the mission constraints of power, volume, etc. where small mosaic sized elements can be produced for "high resolution" construction of complex shape structures. This would require optimization where producing smaller elements require more energy for a given volume of rocks. However, producing smaller size blocks requires lighter and more compact hardware.

In a future exploration on Mars, a rover would be assigned the task of preparing for human landing in addition to such objective as samples acquisition for return to Earth in compliance with the Decadal Survey science objectives. Offering a dual use of the hardware that would be placed on Mars as part of the mission would allow the most effective use of the mission resources and would make the establishing of the necessary infrastructure for human landing more affordable. Rock samples could also be analyzed for their scientific value including:

- Determine history and characteristics of the formation of the parent body from the cored material.
- Identify fossilized materials
- Conduct geochronology of samples history.
- Thin sections can be easily made to preform pretrographical studies.
- CT scans can identify internal structure for both formation and fossil identification
- Volatiles escape from cuttings during the drilling process but would be more readily retained at the center of a consolidated core.

Acquisition of cores/bricks can identify internal weathering either through stratigraphic formation or through the billions of years of surface weathering that has occurred to the sample. By sub-sampling material, layers of interest can then be "subsampled" and analyzed without being diluted by the rest of the sample.

Further, there are several scientific experiments focused on future human missions that could be conducted through acquisition of a standard size cores, including:

- The understanding of heat flow of Martian materials by setting up an isobaric surface in contact with one end of the core and measuring time dependent temperatures.
- Quantifying the radiation blockage of Martian material by placing a core directly on a radiation detector.

References:

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