Fundamental Regolith Properties, Handling and Water Capture (FLEET) Project Update. L. Gertsch[1], J. Pierce[2], B. Compton[2], T. Krause[2], J. Mantovani[3], J. Stewart[2], E. Rezich[2], M. Proctor[2], F. Thomas[2], [1]NASA Glenn Research Center/Missouri University of Science and Technology (Leslie.Gertsch@nasa.gov), [2]NASA Glenn Research Center (Jennifer.L.Pierce@nasa.gov, Beau.M.Compton@nasa.gov, Timothy.S.Krause@nasa.gov, Erin.T.Rezich@nasa.gov, Margaret.P.Proctor@nasa.gov, Fransua.Thomas-1@nasa.gov), [3]NASA Kennedy Space Center (James.G.Mantovani@nasa.gov).

Introduction: The FLEET project, begun in FY21, was designed to research several concepts for components and subsystems needed for extracting water from planetary ice deposits. This is one of two approaches for providing water off-Earth for direct use and also for feedstock to manufacture spacecraft propellants. The other approach is to extract lattice-bound water and hydroxyl from the minerals that make up the solid grains of rock and regolith.

The ultimate intent is to integrate the findings with other efforts, such as [1], in the creation of complete water-from-ice production systems for various downstream uses [2]. The project consists of several elements, now in various stages of completion. They are presented here in the approximate order they would generally be applied to a water-extraction system: Digging icy regolith, transporting it, capturing water vapor, and sealing chambers from the outer environment.

Ultrasonic Blade: This element is evaluating the effect on digging force and energy expenditure of incorporating ultrasonic vibration in the portion of an excavation tool that contacts the regolith [3]. A test article is being readied for a series of lunar-gravity performance experiments scheduled shortly before this Roundtable.

Bulk Water Stability: The impetus for this element was the observation that the majority of water lost during drill sampling of icy regolith simulant in a vacuum chamber occurred during brushing the clinging simulant grains from the drill bit [4]. This experiment, still being designed, will help characterize the amount of water vapor loss throughout the excavation and production system, necessary for evaluating total system performance.

Mobile Water Extractor: This element evaluated how much water could be lost through volatilization of ice from loose regolith exposed to lunar surface atmosphere by mismatching seals [5]. Within the range of two-dimensional edge mismatches tested between a cryotrap and a surface of ice-doped regolith simulant, the water capture efficiency was affected less than predicted by a model that assumed molecular gas flow.

Vertical Regolith Transport: This element is adapting current-art spiral conveyor technology with stick-slip particle motion, to transfer excavated icy regolith to storage bins or inlet hoppers. A test article for this is being finalized for a separate set of lunar-gravity experiments [6].

Columnated Soil Seal: This study examined the efficacy of masses of dry regolith, poured loosely in cylindrical columns, for sealing pressurized chambers beneath. Ambient-pressure and vacuum experiments, and a numerical model verified by the data, show that soil seal performance is controlled by the depth of dry regolith, as well as by the ratio of regolith depth to column diameter [7].

Water Capture: Transferring the water product from the extractor to downstream uses is easiest when it is solid rather than vapor or liquid. To that end, this element is investigating the effects of various environmental parameters on the density of water ice precipitated on cold surfaces (nominally one dimension of growth) in vacuum [8]. This will inform the design of ice tankers and how they can best be scheduled in a production system.

Next Steps: The research being done by the FLEET project continues to advance understanding of the behavior and limitations of component technologies that are needed in systems to produce oxygen from water ice. More such work is needed, however, before a complete water extraction system can be designed for the Moon.

References:

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