EXPERIMENTAL RESULTS OF SUBLIMATION LOSS FROM OPEN-GAP LUNAR WATER EXTRACTION. T. S. Krause[1], F. Thomas[2], and L. Gertsch[3], [1]USRA, NASA Glenn Research Center 21000 Brookpark Road, Cleveland, OH 44135 timothy.s.krause@nasa.gov, [2]NASA Glenn Research Center 21000 Brookpark Road, Cleveland, OH 44135 fransua.thomas-1@nasa.gov, [3]Missouri S&T, NASA Glenn Research Center 21000 Brookpark Road, Cleveland, OH 44135 leslie.gertsch@nasa.gov.

Introduction: As humans return to the Moon and reach for Mars, the use of materials native to the environment through in-situ resource utilization (ISRU) is of utmost importance. One critical resource is water, from ice contained within the lunar regolith, for use with life support or propellant supply. While the careful capture of each water molecule within hermetically sealed extraction chambers intuitively seems most efficient, such seals increase the mass and complexity of the system.

This research, along with previous work for Mars [1,2], examines the feasibility of extracting water from icy regolith in the lunar environment with an open-gap (seal-less) system: how much of the water ice in an ice-regolith mixture can be captured by a system that leaves narrow but open gaps between a tray of heated regolith simulant and a cryotrap?

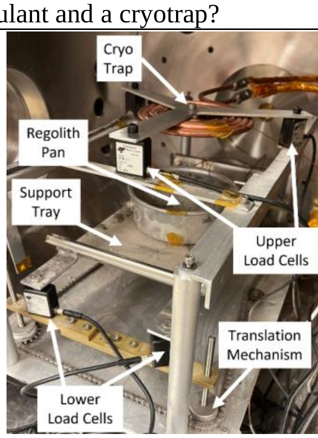

Fig. 1. The experiment configuration, installed in the CW-14 2-ft vacuum chamber at NASA GRC.

Experiment: The test device (Fig. 1) consists of a pan filled with a pre-chilled, pre-doped, loose mixture of 8 wt% water and 92 wt% NU-LHT-3M lunar regolith simulant. Centered above the regolith pan is a coiled-tube cryotrap to capture freed water vapor. Pan diameter and vertical distance between pan and cryotrap are adjusted to form different gap dimensions.

During a test, the chamber is first pumped down to 10^{-3} torr, at which point the pump is turned off. The regolith pan is then heated from below for the remainder of the test. As the ice heats to vapor, mass loss from the regolith pan and mass gain by the cryotrap are recorded, as well as chamber pressure and temperatures at various points within the pan.

In addition to the horizontal and vertical gaps, the heat flux was also varied during the test campaign. Each test was run for five hours after the heater was turned on, and each test point was repeated twice.

Results: After the pump was turned off (denoted as time=0 min in Fig. 2), the chamber pressure increased for about 70 min while no ice collected on the cryotrap. After the pressure reached about one torr, linear mass loss from the pan / mass gain by the cryotrap was observed for remainder of the test. Unexpectedly, the capture efficiency (ratio of mass loss from the pan to mass gained at the cryotrap, represented by the black line in Fig. 2) appears relatively insensitive to horizontal gap, vertical gap, or heat flux in the current range of experiment configurations. More intuitively, as the pan diameter and therefore surface area increased, more mass was freed from both the regolith pan and deposited at the cryotrap. The rate of change of both masses also increased with increasing pan diameter.

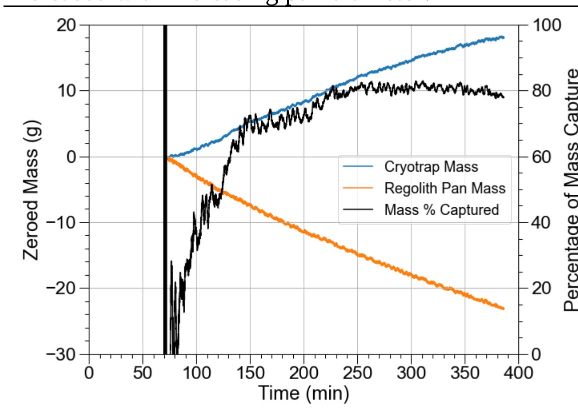

Fig. 2. Representative mass curves shown here for 2.5-cm horizontal gap, 5.1-cm vertical gap, and 620 W/m^2 heat flux.

Conclusion: Within the limits of the experiment setup, loss of volatilized water ice from heated ice-regolith simulant mixtures is less sensitive to the size of open gaps than expected. A mass capture ~80% was measured in this open-gap configuration.

References: [1] Linne, D. L. et al. (2016) *9th Symposium on Space Resource Utilization*, 0226. [2] Trunek, A. J. et al. (2018) *Earth and Space: Engineering for Extreme Environments*, 490-500.