Title: Advanced Thermal Mining Approach for Extraction, Transportation, and Condensation of Lunar Ice

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Development Objectives: The proposed research aims to develop and demonstrate an advanced thermal mining technology of 1 kg ice collection capacity that integrates engineered extraction, transportation, and condensation of water vapor from lunar regolith. The objectives of the proposed effort are to (a) experimentally measure the thermophysical properties of icy regolith including specific heat and thermal diffusivity, (b) characterize the thermally-assisted sublimation technologies for icy regolith at various depths and concentrations in a cryogenic vacuum environment, (c) effectively transport rarefied water vapor to a cold trap using vapor ionization and electric field-induced pathway, (d) demonstrate efficient ice collection in a high capacity engineered cold trap consisting of a cryogenic flat heat pipe condenser plate and a vapor lubrication system for intermittent ice delamination, and (e) extract, ionize, and deposit the rarefied water vapor in an integrated lab-scale prototype and perform system-level scale-up analysis.

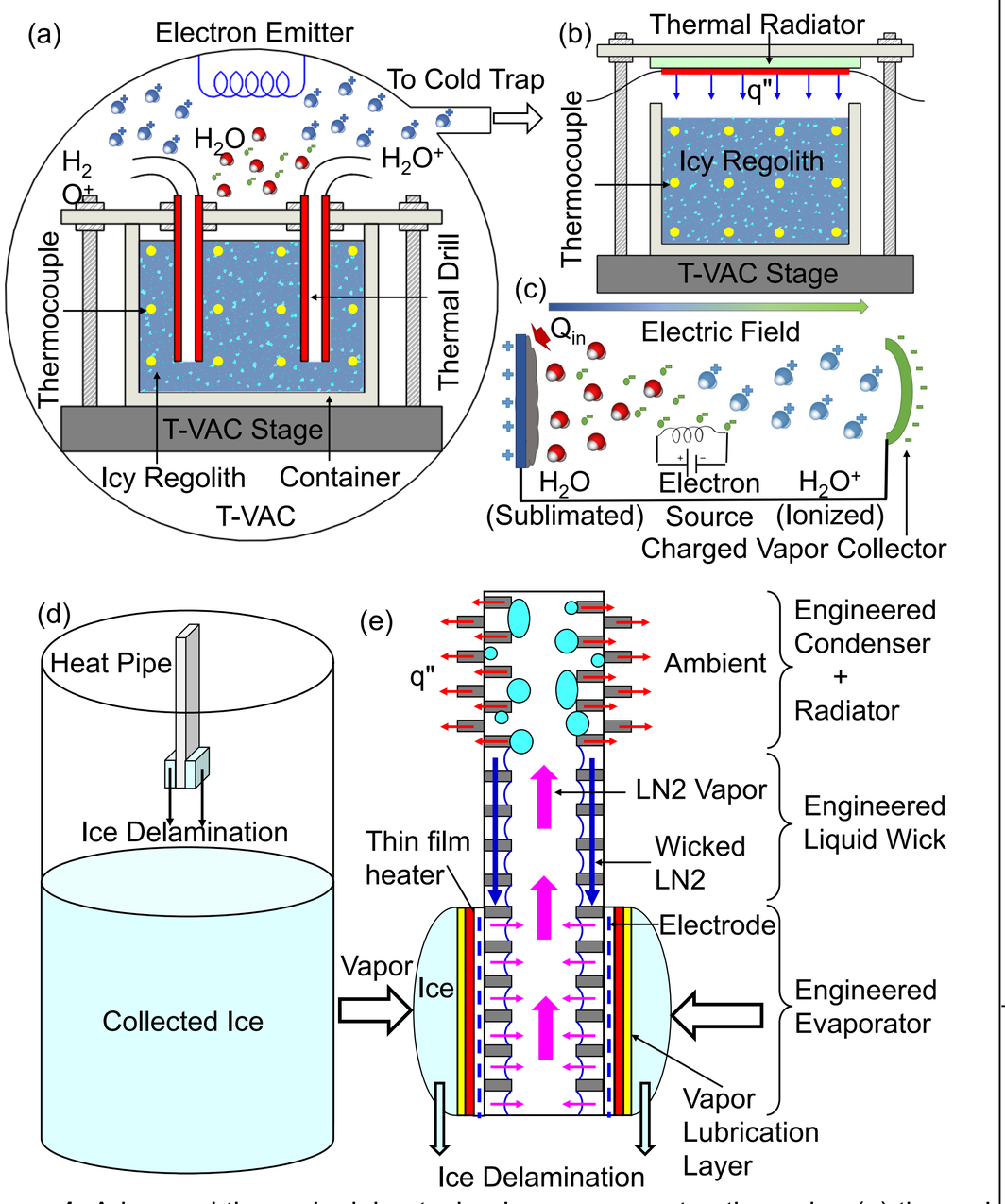

Figure 1: Advanced thermal mining technology: vapor extraction using (a) thermal drilling (b) radiative heating, (c) vapor ionization and transportation by electrostatic field, (d) ice re-capture in cold trap and (e) heat pipe surface engineering

Approach: The proposed effort aims to: (i) measure thermophysical properties of icy regolith simulants, (ii) perform kinetic studies of water sublimation from icy regolith simulants, (iii) experimentally compare the sublimation rates at various concentrations and depths from capture tent and thermal drill technologies, (iv) ionize sublimated water vapor and transport to the cold trap by electrostatic field, (v) design, fabricate and demonstrate a 1 kg ice capacity cold trap with engineered cryogenic heat pipe, (vi) extract, ionize and deposit ice in integrated lab-scale prototype system, and (vii) system-level scale-up analysis of the proposed thermal mining technology.

Impact and Infusion: A preliminary analysis was done to explore the integration of the proposed effort with the Augur-based thermal mining technology currently being developed at NASA JSC Energy Conversion Systems (EP3) Branch. In alignment with Lunar ISRU architecture, a full scale Augur integrated system can support the production of 10 tons of O2 in 225 days. A pilot-scale can also be envisioned to take advantage of the Commercial Lunar Payload Services.