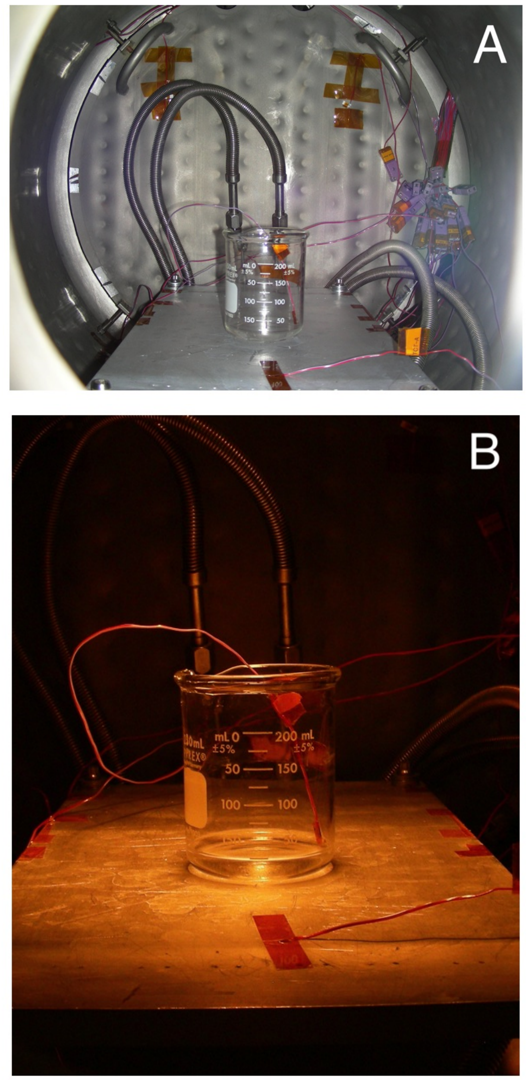
RATE OF EVAPORATION OF WATER UNDER LOW-PRESSURE CONDITIONS. E. M. Carey[1], J. Castillo-Rogez[1], J. E. C. Scully[2], C. T. Russell[2], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA (elizabeth.m.carey@jpl.nasa.gov), [2]Dept. of Earth and Space Sciences, University of California, Los Angeles, CA, USA (jscully@ucla.edu).

Introduction: Recent observations of geomorphological features on asteroid Vesta, in particular sub-curvilinear gullies found on the walls of craters Cornelia and Marcia, have been attributed to the transient flow of liquid water from subsurface ice-bearing deposits, following a crater-forming impact [1]. For these features to have formed in this way, it is necessary that a significant portion of the water remained in a liquid state for at least tens of minutes. However, the natural state of water in the surface conditions of airless bodies is either in the form of ice or vapor that escapes in low gravity environments. Hence the stability of liquid water on an airless body such as Vesta requires specific circumstances. We explore several hypotheses for processes that could delay and/or compete with evaporation and freezing.

We suggest that the possible cause for the delay in freezing of the liquid water is similar in mechanism to terrestrial rivers under freezing conditions. That is, despite sub-freezing temperatures, the dynamics of water flowing down the crater wall will be enough to keep the liquid water from freezing for a short period of time [2]. Additionally, we propose the mechanism by which the evaporation of a liquid state is delayed is either an increase in surface tension or decrease in surface area or a combination of both, as consequences of the presence of particulates incorporated in transient flow. As a first step, we investigated the latter hypothesis with a set of experiments of gradual complexity. These are being performed in the Extraterrestrial Material Simulation Laboratory (EMSiL) at the Jet Propulsion Laboratory.

Experimentation: Our experimental set up consists of a 21.2 cubic foot custom Kurt J. Lesker environmental vacuum chamber and several glass vessels of different sizes. In later experiments, we also used approximately 100 grams of AGSCO 100-170 µm glass beads. The glass vessels used in these experiments covered a range of geometries to account for surface tension due to the walls of the container. Ultimately, we found that a 250 ml beaker was best suited for our purposes in that we could rule out wall effects. Temperature of the interior of the chamber and the water inside the beaker were recorded with *LabVIEW*, as well as the pressure inside the chamber.



Figures A and B are images of the experimental set up inside the Lesker environmental vacuum chamber. The visible wires are thermocouple temperature sensors.

The first test consists of a beaker with 25 ml of liquid water at a temperature of ~20°C. The pressure inside the chamber was decreased to ≥2.86 Torr and we found it took ~150 minutes for all of the water to evaporate.

In practice, it is unlikely that pure water would be released as a consequence of an impact. Instead we would expect that liquid to be loaded with rock particles. In order to test the effect of particles we mixed equal part (by weight) of glass beads of diameter 100-170 μm and water.

Key Results: We found that it took ~150 minutes to evaporate 25 ml of ~20°C water with a pressure of ≥2.86 Torr during the experiment. When 25 grams of 100-170 μm glass beads were added to 25 ml of water, we found it took ~300-360 minutes for the water to evaporate. Thus, the addition of glass beads resulted in increasing the evaporation time by a factor two.

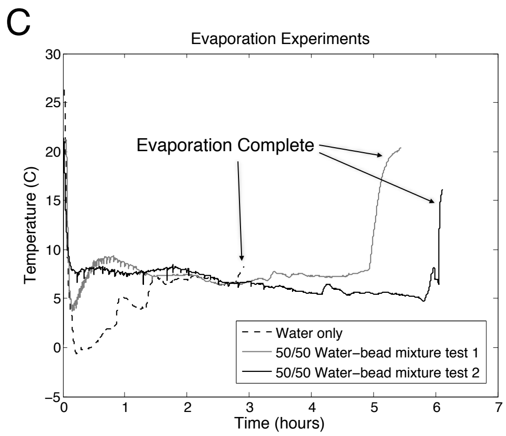


Figure C shows 3 experiments performed using at 25 ml beaker, one with water only and two with a 50/50 mixture of water and 100-170 μm beads. All 3 tests were performed using the 25 mL of water.

We attribute this behavior to the combination of two phenomena: surface tension and decrease of the surface area of liquid exposed to vacuum. The surface tension of the water is increased due to evaporative cooling and the presence of the particulates. As the water evaporates, the temperature decreases and surface tension increases. In addition, the particulates decrease the surface area of water exposed for evaporation.

Future Experiments: In our second stage of experiments, we are examining the relationship between the evaporation rate of liquid water to the composition and average grain size of the impurities under low-pressure conditions. The purpose of this investigation is to quantify the respective role of surface tension and surface area in the rate of evaporation. We will report on these ongoing experiments. Also we have designed an apparatus to specifically test the conditions under which water remains in a liquid state as it flows down a slope, in conditions of pressure and vacuum analogous to Vesta's surface, in order to simulate the scenario proposed by [1] for the formation of the sub-curvilinear gullies.

Implications: Understanding the conditions for water to remain liquid at the surface or airless planetary bodies for extended periods of time bears important implications. In particular it has been suggested that impact-induced water release could promote hydrothermal chemistry responsible for hydration features observed at the surface of certain asteroids [3]. The extent of hydrothermal alteration would be in part determined by the time during which liquid water remains available. This question is of particular interest to the dwarf planet Ceres that is believed to host water ice a few hundred meters below its surface [4].

References: [1] Scully J. E. C. et al. (2014) *LPSC XXXXV*. [2] Ashton, G. D. (1978) *Annual review of fluid mechanics 10.1*. [3] Zolotov Y. (2014) *Icarus* 228, 13-26. [4] Castillo-Rogez, J. C. (2011) *Icarus* 215, 599-602.

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