DELAYED RELEASE AND DELIVERY OF VOLATILES TO POLAR RESERVOIRS. P.H. Schultz, Brown University, Geological Sciences, 324 Brook St., Box 1846, Providence RI, 02912-1846 (peter_schultz@brown.edu)

Introduction: Recent missions demonstrate that volatiles (OH, H_2O) cling to the lunar regolith grains [1,2,3], especially near the poles [4,5,6] along with other mobilized species such as CO, CO_2, Cl, N, and S [7,8]. Mechanisms for delivering these volatiles include: solar wind implantation or replacement [9,10]; collisions by volatile-rich asteroids and comets [e.g., 10,11]; and trapping within the impact glasses [12].

Background: The LCROSS impact also excavated a wide variety of elements stored at South Pole, including Na [7,13] as well as Hg, Au, Mn, Si, P, Zn, Fe [8], and Ag [7]. Consequently, highly volatile elements and compounds are not the only components trapped near the poles. These additional components could have come from trapped "old" components that date from the last stages of lunar volcanism or from recent degassing events [e.g., 14]. Or they represent impact-released migrants. Here we explore one mechanism that could temporarily store and release volatile elements/compounds at small scales (by impact-injection into the regolith) and at large scales (by release from gases trapped in impact melts).

Laboratory Experiments: At the NASA Ames Vertical Gun Range, quarter-space experiments allow looking inside a hypervelocity impact crater. High-speed spectrometers probe emission lines created by impact-generated vapor while high-speed cameras capture the evolving phenomenology. Quartz fibers from four separate telescopes (2.5cm field of view) are connected to one of two 0.35m spectrometer. Dolomite targets provide a surrogate target in order to interpret processes created by much higher speed impacts into silicate targets.

During the first 50μs, disassociation products (Ca, C_2, and Mg) dominate the spectral emissions (**Fig. 1**). Disassociation products (CaO and CO) represent minor constituents at early times (first 5μs) but dominate the signal later. The greatest intensities occur above, while vapor within the crater cavity ("below") fills the growing cavity.

The relative intensities of calcium lines change depending on time and location, reflecting contrasting temperatures in a non-uniform vapor plume. Above the surface, the 615.6nm Ca emission line corresponds to a low-T component directed uprange. This low-T component also means a low thermal expansion speed

Discussion: Impact-generated vapor exhibits a wide range of conditions depending on location. Below, low-temperature vapor fills the transient cavity, indicating that a component will be injected between (or condensed on) regolith grains. Above, free expansion of high-T vapor exceeds escape speeds.

Consequently, small impacts into in the regolith could temporarily retain traces of both high-T and low-T byproducts trapped below the crater floor or wall. This process also occurs for impactor components. For example, even high-angle impacts (60°) by glass spheres (0.635cm) into solid copper and basalt targets leave behind intact fragments as large as 200μm (some retaining the surface projectile surface). The much higher impact speeds on the Moon will generate higher temperature vapor; nevertheless, the process of injecting, depositing, and retaining low-T products still applies. Consequently, volatiles should be temporarily stored beneath small (<1m) craters in the regolith. Thermal cycles (as well as impact gardening) later release these components gradually with a much lower kinetic temperature, enabling trapping at the poles.

Implications: Release of regolith-stored volatiles from small impacts (and from cooling melts within large, recent craters) represents reservoirs that gradually supply volatiles to polar cold traps. Such a process would offset losses such as impact gardening.

References: [1] Sunshine, J. M. *et al.* (2009), *Science*, **326**, 565-568; [2] Pieters *et al.* (2009), *Science*, **326**, 568-572; [3] Clark, R. N. (2009), *Science*, **326**, 562-564; [4] Spudis, P.D. *et al.* (2010) *GRL*, **37**, L06204, doi: 10.1029/2009GL042259. [5] Bussey, D. B. J. *et al.*, *LPSC 42*, no. 2086; [6] A. Colaprete *et al*. (2010), *Science*, **330**, 463-468; [7] Schultz, P. H. *et al*. (2010), *Science,* **330**, 468-472; [8] Gladstone, R. *et al.* (2010)*, Science*, **330***,* 472-476; [9] Stern, A. (1999), *Revs. of Geophys.*, **37**, 453-491; [10] Potter, A. E., Morgan, T. H. (1988), *Science*, **241**, 675-680; [11] Ong, E. *et al*. (2009), *Icarus*, **207**, 578; [12] Harris *et al*., R. S. (2007), *LPI Contrib. No. 1360*, abstract # 8051; [13] Killen *et al*., GRL, 37, L23201; [14] P. H. Schultz *et al*. (2006), *Nature,* **444**,184-186.

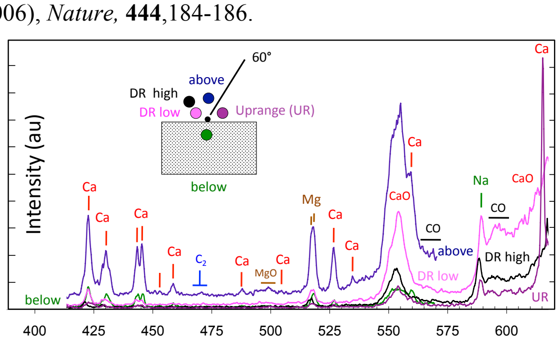

Figure 1: Emission lines created by excited species during the first 50μs within the vapor plume (1/4" Pyrex at 5.72km/s). Different colors correspond to different fields of view (~2.5cm). Note the "cool" (Ca, 615.6nm) line that dominates the uprange vapor component. Intensities are in arbitrary units.