A Model for the Distribution of Volatiles at the LCROSS Impact Site. A. Colaprete[1], J. Heldmann[1], D. H. Wooden[1], K. Mjaseth[1], M. Shirley[1], W. Marshall[1], R. Elphic[1], B. Hermalyn[2], P. Schultz[2], [1]NASA Ames Research Center, Moffett Field, Anthony.colaprete-1@nasa.gov, [2]Brown University, Department of Geological Sciences, Providence, RI.

Introduction: Using the spent Centaur booster as an impactor, the Lunar Crater Observation and Sensing Satellite (LCROSS) mission sampled one spot within the South Pole crater Cabeus by lifting material from shadow and into sunlight. The LCROSS Shepherding Spacecraft (SSC) flew four minutes behind the impacting Centaur making measurements of the impact, debris clouds, and resulting crater [1]. At the same time, measurements were made by instruments onboard the Lunar Reconnaissance Orbiter (LRO), including the Lyman Alpha Mapping Project (LAMP) spectrometer at impact and the Diviner Lunar Radiometer (DLR) approximately 90 seconds after impact [2,3]. These various observation platforms provided a number of unique and complimentary measurements of the impact. This paper presents an attempt to piece together the conglomerate of observations into a single model for the surface conditions at the LCROSS impact site. In particular, the model addresses the distribution and form of the various volatiles, including water, observed in the LCROSS impact event.

LCROSS Impact Location: The LCROSS Centaur impacted into an area in the crater Cabeus which has been in permanent shadow for the more than one Gyr4]. The impact site was selected based on a variety of criteria, including the presence of hydrogen, temperatures, height to sun illumination, and slopes. Leading up to the final impact target selection, LRO data was used to understand these parameters with nearly continuous updates coming from the LRO instrument teams. The two most important criteria were hydrogen concentrations and height to sun illumination.

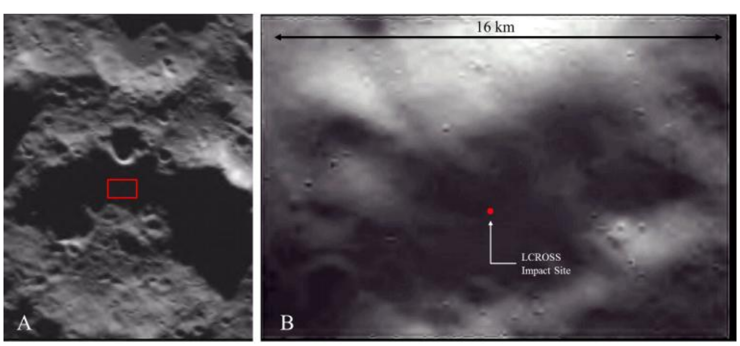

Figure 1. Images taken from a NIR Camera #2 on the LCROSS Shepherding Spacraft at an altitude of approximately 145 km (panel A) and 43 km (panel B) above the surface of Cabeus. The area is in permanent shadow and illumination is the result of light reflected/scattered off adjacent terrain (sun is to the upper left, while the inner walls of small craters in panel B indicate illumination from the bottom of the image).

The LCROSS impact site, imaged by the LCROSS NIR camera and registered to LOLA DEMs [5, 6], was in a depression that would have provided extra shadowing from secondary scattering from surround terrain. It is in these "double-shadowed" areas that temperatures are theoretically coldest (Figure 1).

Characteristics of the Impact and Impact Site: The impact resulted in a two-component ejecta curtain: a high angle plume which has been associated with the low density of the impactor, and the canonical "low angle" curtain, which, while similar to traditional natural impacts, was also modulated by the density of the impactor [5]. Based on the nature of the NIR and visible impact flashes the impact site appears to be relatively low density (porosities >70%) [5]. While the impact generated relatively cool and localized debris (T~1000-1200 K), a variety of vapors were released at impact (including CO and H_2) [2]. Other vapor components (e.g., Na) appear only after the first dust is seen via scattering of sunlight, suggesting some of the volatile components were intimately entrained in the soil/ice mixture [5]. Water ice grains were observed in the ejecta at early times (Impact +20 sec), and again at later times (Impact+230 sec). This observation suggests that these grains were at least part of the high angle ejecta cloud and most likely also in the nominal angle ejecta component [1,7,8]. Increases in water vapor with time after impact suggest exposed water at the impact site. The cold temperatures within the Centaur crater (as observed by the NIR and as observed by Diviner) indicate a possible ice rich soil [1, 3]. Combined, these observations help constrain the types and distribution of volatiles at the LCROSS impact site. This paper will present a summary of the observations and an evaluation of various models for the distribution and form of volatiles at the LCROSS impact site.

[1] Colaprete et al., (2010), *Science*, **330**, 463-468. [2] Gladstone et al., (2010), *Science*, **330**, 472-476. [3] Hayne et al., (2010), *Science*, **330**, 477-479. [4] Paige et al., (2010) *Science*, **330**, 479-482. [5] Schultz et al., (2010), Science, 330, 468-472. [6] Marshall et al., (2011), *PSS*, In Press. [7] Colaprete et al, 2011, 42nd LPSC , abs# 2037. [8] Hermalyn et al.(2011), Wet vs. Dry Moon Workshop, LPI.