Shooting the Moon: A Review of the LCROSS Results. P. H. Schultz[1], A. Colaprete[2], B. Hermalyn and the *LCROSS Team*. [1]Brown University, Providence, RI 02912-1846 (peter_schultz@brown.edu), [2]NASA Ames Research Center, Moffett Field, CA 94035

Introduction: The *Lunar Crater Observation and Sensing Satellite* (LCROSS) mission used the detached and emptied upper stage rocket (Centaur) to impact the lunar surface near the lunar South Pole in the crater Cabeus (1). Instruments on board the trailing *Shepherding Spacecraft* (or "*SSc*") recorded the evolution and composition of the resulting ejecta as they reached sunlight ~830m above the crater floor.

First Light: The Mid-Infrared (MIR) cameras on the *SSc* recorded "first light" in the first frame after impact and remained visible in multiple frames thereafter. The duration of the MIR "flash" indicated an impact into a porous regolith, rather than a solid surface. The *Near-Infrared Spectrometer* (NSP1) operated in a "flash mode" (1ms integration times) during the time of impact, thereby functioning as a thermal flash detector. The NSP1 revealed a relatively slow rise in radiance that peaked after 0.3sec (but began about 0.3 second after the moment of contact). This is interpreted as an expression of a highly porous upper surface layer [2]. The *UV/VIS Spectrometer* (VSP) captured the moment of impact expressed by a number of atomic and molecular emission lines including CO_2, NH, and OH. Because there was no rise in background, these first-appearing species are interpreted as volatiles excited by the energy of the impact (not sunlit components).

Evolving Compositions: The next 2-second exposure exhibited an elevated thermal background, thereby confirming the arrival of ejecta into sunlight. Thereafter, other volatile species emerged as emission lines, including Na, NH_2, and H_2O^+. Hydroxyl absorptions exhibited band strengths that rapidly increased, peaking ~17sec after impact and then leveling-out between 70sec and 200sec before falling to pre-impact levels. The near infrared spectrometer (NSP) captured absorptions due to water molecules (and other H-species) over most of the approach.

The visible (VIS) camera revealed that the ejecta cloud did not exhibit the expected expanding ring of ejecta. Rather, it emerged as a diffuse cloud, persisting longer than expected. Laboratory impact experiments [2] reveal that the low-density nature of the Centaur upper stage should have produced a high-angle plume, in addition to the classic advancing ejecta curtain. Moreover, experiments also reveal that the earliest stages of ejection result in ejection angles much lower than usually assumed, the multi-pixel component in the first MIR images [3].

Final Moments: Just prior to impact, changes in exposures and sensitivity of the NIR detector allowed imaging the shadowed surface during the final stages of approach. These images revealed a "ghost-like" feature moving across the scene. This feature is interpreted as sunlit ejecta still-returning to the surface. The diameter of the cloud requires very high-angle ejection angles, very similar to the laboratory experiments [2]. The location of the Centaur crater was identified in NIR images by correlation with a warmed region in MIR images during final approach. The crater is about 20-30m in diameter and appears as a dark (cooler) interior surrounded by a lighter colored (or slightly warmer) ejecta deposit.

Conclusions: The total amount of water-ice reaching sunlight represents a concentration of about 4-8%. This, however, represents only the sunlit fraction from the upper surface with speeds sufficient to reach an altitude of ~830m. The lowest speed ejecta (and from the greatest depths) never reached sunlight and would have represented the greatest excavated mass. Consequently, the derived concentrations might only provide a hint of the reservoir of volatiles trapped in permanent shadows at greater depths.

The existence of a variety of light hydrocarbons and other volatiles resemble constituents of primitive bodies, such as asteroids and comets. In addition to the flux of solar particles [4,5,6], hypervelocity collisions might be contributing to the volatile inventory

References:
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