SCIENCE OBJECTIVES OF A MISSION TO THE LUNAR PERMANENTLY SHADOWED REGIONS. D. M. Hurley[1], P. Prem[1], A. Stickle[1], C. Hibbitts[1], A. Deutsch[2], A. Colaprete[3], R. Elphic[3], S. Li[4], P. Lucey[4], Y. Liu[5], S. Hosseini[5], K. Retherford[6], K. Zacny[7], J. Atkinson[7], M. Benna[8], W. Farrell[8], D. Needham[9], L. Gertsch[10], P. Hayne[11], and M. Delitsky[12]. [1]Johns Hopkins University Applied Physics Laboratory (dana.hurley@jhuapl.edu), [2]Brown University, [3]NASA Ames Research Center, [4]U. Hawaii, [5]Jet Propulsion Laboratory, [6]Southwest Research Institute, [7]Honeybee Robotics, [8]NASA Goddard Space Flight Center, [9]Marshall Space Flight Center, [10]Missouri S&T U., [11]U. Colorado, and [12]California Specialty Engineering.

Introduction: One decade ago, an Atlas V rocket launched from Kennedy Space Center in Canaveral, FL carrying Lunar Crater Observation and Sensing Satellite (LCROSS) and Lunar Reconnaissance Orbiter (LRO) to the Moon. Within a few months, astounding new results from Chandrayaan-1, Deep Impact, and Cassini revealed at spectral signature of OH on illuminated regions of the Moon [1-3]. Then, the planned impact of LCROSS into the permanently shadowed region (PSR) Cabeus revealed that plentiful volatiles, including H_2O, CO_2, CO, Hg, and Na, are stored in at least some locations in PSRs [4-9]. Soon thereafter, the National Research Council conducted the Planetary Science Decadal Survey [10]. The Lunar Polar Volatiles Explorer concept [11] was studied for consideration in prioritization for potential NASA missions. That study resulted in a rover that would explore a PSR on the Moon to determine the lateral and vertical distribution, chemical composition and variability, isotopic composition, physical form, and rate of change of volatiles.

In the intervening years, significant progress continues on understanding volatiles on airless bodies. For the next decadal survey, it is important to use the evolution of our understanding of volatiles to formulate potential NASA missions. Here, we consider the potential scientific objectives of a mission to the lunar PSRs.

Discussion: We will examine a mission to a lunar PSR if our proposal to the NASA Planetary Mission Concept Study is selected. Here we present some of the compelling science that can be achieved in such a mission.

Ground-truthing. The significant database of remote sensing observations has been interpreted regarding lunar volatiles abundance, distribution, composition, and physical form. However, these are expected to vary on spatial scales smaller than the resolution of the remote sensing data. Therefore, in situ measurements provide the crucial ground-truth to our existing data sets.

Distribution and Abundance. The distribution and abundance are somewhat known, although there is more work to be done. The most compelling questions that remain are those surrounding the processes that modulate these quantities. Potential factors include the age of the deposits, the thermal environment, exposure to space, impact processes, and gas-surface interactions.

Composition and Chemistry. The original source(s) of PSR volatiles provided the initial composition of PSR volatiles. However, these have been modified over time based on relative volatility, interaction with surfaces, potential reactions spurred on by cosmic ray and impacts. Thus, the present-day composition, how it varies, and the isotopic make up of PSR volatiles is an important measurement to understand the sources and processes affecting PSRs.

Activity and Transport. Processes that are ongoing today have the potential to be significant influences of PSR volatiles. Even minor sources or losses can accumulate to be a significant process compared to more rare occurrences. Measuring the present-day rate of mass loss or addition and the physical mechanism for it enables tracking the present contents of PSRs back in history.

Thermophysical and Geotechnical Properties of PSRs. In addition to being a reservoir for volatiles, lunar PSRs are interesting as an extremely cold, low pressure environment. The thermal and geotechnical properties of the regolith are not well understood. In addition to revealing how materials behave in this extreme environment, knowing the geotechnical properties is crucial for any future development of lunar volatiles as a resource.

Conclusion: Volatiles remain an important scientific endeavor for understanding the evolution of planetary bodies, the formation of the solar system, and processes ongoing on airless bodies immersed in a hostile space environment. Many significant results await future orbiters, landers, rovers, penetrators, and sample return missions to reveal them.

References: [1] Pieters et al., *Science 326,* 2009; [2] Sunshine et al., *Science 326*, 2009; [3] Clark, *Science 326*, 2009; [4] Colaprete et al., *Science 330,* 2010; [5] Gladstone et al., *Science 330,* 2010; [6] Paige et al., *Science 330,* 2010; [7] Mitrafanov et al., *Science 330,* 2010, [8] Schultz et al., *Science 330,* 2010; [9] Killen et al., *GRL 37,* 2010; [10] Squyres et al., *Nat. Acad. Press,* 2011; [11] Shearer et al., 2012.