MINI-RF MONOSTATIC RADAR OBSERVATIONS OF PERMANENTLY SHADOWED CRATER FLOORS. L. M. Jozwiak[1], G. W. Patterson[1], R. Perkins[2], [1]Planetary Exploration Group, Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, [2]Department of Earth and Environmental Sciences, Wesleyan University, Middletown, CT, USA (lauren.jozwiak@jhuapl.edu).

Introduction: The identification of water in the polar regions of the Moon has been a significant finding for both the lunar scientific and exploration communities [1, 2]. Following the Lunar Crater Observation and Sensing Satellite (LCROSS) experiment impact into Cabeus crater [3], efforts were made by several other instruments to identify the source of the water observed in the impact plume [4]. Water ice has the diagnostic characteristic of a circular polarization ratio (CPR) > 1, and as such, should have been readily identifiable in Mini-RF data. However, observation of both Cabeus crater and the LCROSS impact site itself by the Mini-RF instrument revealed circular polarization ratio (CPR) values comparable to, or lower than the surrounding south polar terrain [5]. This observation suggested that, if present, the water ice must be in the form of small (< ~10 cm), discrete pieces of ice distributed throughout the regolith, or as thin coating on ice grains.

Since that time, evidence has grown for the presence of water ice (of some form) located in the permanently shadowed regions (PSR) of the Moon [6, 7], and the continued operation of the Mini-RF instrument has allowed for the production of high-resolution polar mosaics of the CPR data. These polar mosaics have allowed for an expanded analysis of CPR values for multiple permanently shadowed craters at both the north and south pole of the Moon.

PSR Crater Analysis: This analysis focused on comparing the radar response of permanently and non-permanently shadowed regions of both north and south polar lunar craters. The analysis regions were constructed using LOLA-based shadow models and LOLA-based slope maps. Because sloped surfaces (such as crater walls or peaks) can result in spurious additions to the returned radar signal, we restricted our analysis to regions with slope less than 5°. These flat regions were then divided into permanently shadowed and non-permanently shadowed regions using the shadow model. Finally, we considered only craters where both the flat permanently and non-permanently shadowed regions were spatially expansive enough to be considered significant.

Our final dataset included 10 north polar craters and 11 south polar craters. Using Mini-RF monostatic polar mosaics generated by the USGS, we used the generated shapefiles to extract CPR values for the permanently and non-permanently shadowed flat crater floor regions. Comparing the distribution of values for the PSR and non-PSR of each crater reveals similar distributions with subtle variations. To better assess the statistical variability of the signal, we plotted the mean ± 1 standard deviation for both the PSR and non-PSR crater floor regions, shown for the north polar craters in Fig. 1. While the majority of the PSR and non-PSR regions have different mean values, when the standard deviations are included, none of the PSR regions are statistically distinct from the non-PSR regions. Specifically, none of the PSR regions show significantly higher CPR returns, as would be predicted for radar interaction with water ice [e.g. 8].

Conclusions: These results are consistent with the results of Neish et al. [2011] [5], and suggest that the water ice present in the permanently shadowed regions of lunar polar craters is unlikely to be present in the form of thick, pure ice deposits. The ice instead, must be confined to small, discrete blocks, or thin coatings on rock grains. Additionally, water ice does not appear to be preferentially concentrated in permanently shadowed regions.

These results are significant for future ISRU efforts in that they suggest that water ice deposits might be equally accessible at thermally stable depths in non-permanently shadowed polar regions.

References: [1] Feldman, W. C. et al. (1998) *Science 281*, 1496-1500. [2] Feldman, W. C. et al. (2001) *JGR Planets, 106*, 2331-23251. [3] Schultz, P. H. et al. (2010) *Science 330*, 468-472. [4] Colaprete, A., et al. (2010) *Science 330*, 463-468. [5] Neish, C. D. et al. (2011) *JGR Planet 116*, E1. [6] Patterson, G. W. et al. (2017) *Icarus 283*, 2-19. [7] Li S. et al. (2018) *PNAS 115*, 8907-8912. [8] Hapke, B. (1990) *Icarus 88*, 407-417.

Figures:

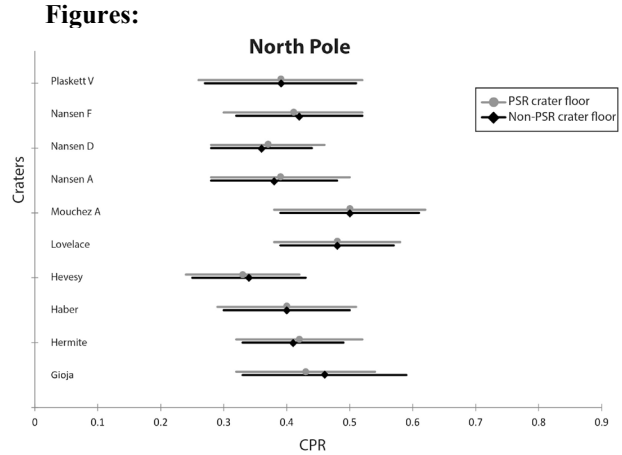

Figure 1: Mean CPR values +/- 1 standard deviation for the analyzed north polar permanently shadowed crater floors. CPR values derived from Mini-RF east-looking mosaics.