

HIGH REFLECTANCE DUE TO PATCHY DISTRIBUTION OF SURFACE ICE SEEN IN INDIRECT ILLUMINATION OF SHADOWED REGION NEAR THE ARTEMIS LANDING SITE. Shanmuga Subramanian¹, Independent Researcher, Chennai, India (ramanean@gmail.com)

Introduction: In the last 25 years, ground as well as satellite-based observations have proved the presence of water ice at North and South poles of the Moon which is distributed only in certain regions within the PSRs [1-6]. Recent research in 2018 concluded that ice may sporadically occur in Lunar North and South Poles at specific regions based on the combined observations using M3, LRO Diviner and LAMP Data [1]. And in addition to the large PSRs, ice can also be trapped at micro cold traps on the surface of the Moon [3]. Finding evidence of ice on Moon is key for future human explorers who may set foot on the Moon near the South Pole [7]

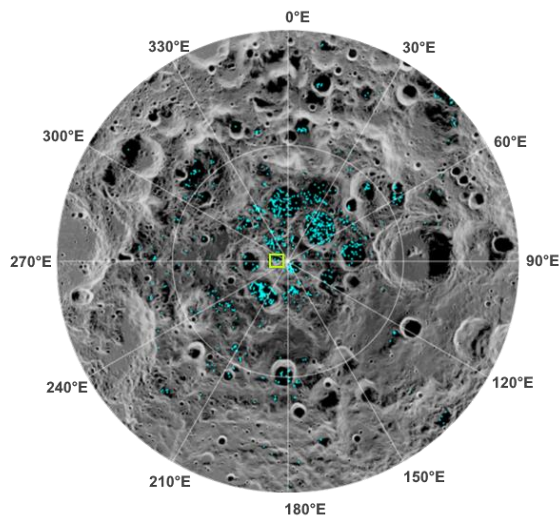


Figure 1: Areas in which direct evidence of patchy surface ice was found [1] with Spudis crater indicated inside the box

Cold traps near the PSR: One such region which may contain water ice is the crater wall of the Spudis crater (Figure 2). This region is close to one of the Artemis 3 landing sites [7]. The region exhibits all characteristics for ice retention [2] and also this area is known to contain patchy surface ice as denoted by the 2018 study[1](Figure 1). In addition to the above factors this region is indirectly illuminated by reflected sunlight from the opposite walls of the Spudis crater even during lunar night at certain solar azimuth angles. This enables us to observe our region of interest in the LROC NAC images at certain incidence and solar azimuth angles.

The region on the crater wall is not a permanently shadowed region but it has a rock outcrop which might trap any volatiles such as ice due to micrometeorite impacts.

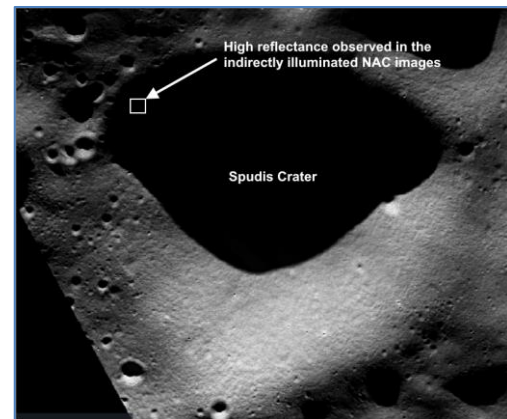


Figure 2: Image of Spudis crater from LROC with high reflectance region marked in a rectangular box

The high reflectance that is observed below -89.32°S , 282.69°E in the brightness enhanced images of M111899810LE (Figure 3-4) might be due to patchy surface ice[1] that has been exposed and mixed with regolith. This high reflectance is also observed nearly dozen other NAC images when the region is not illuminated by direct sunlight at certain solar azimuth angles. Some of them are M111879446L, M11424895R, M111893021R and few others.

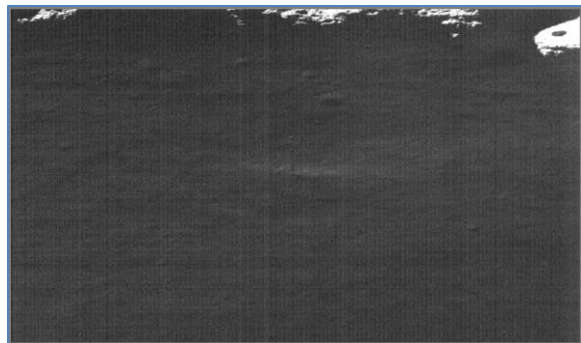


Figure 3: Brightness enhanced LROC NAC image M111899810LE shows high reflectance

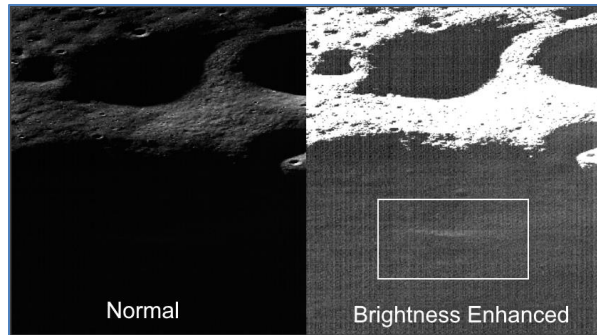


Figure 4: Comparison of normal as well as Enhanced brightness for the image M11899810R showing the high reflectance inside Spudis crater

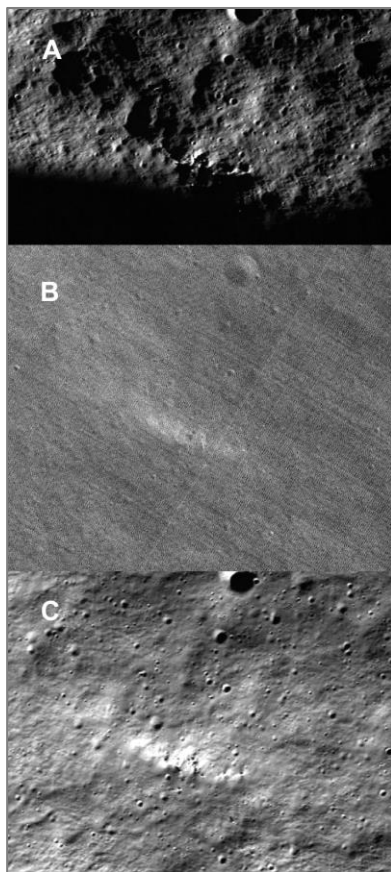


Figure 5: Different images of the same regions with Spudis Crater. 4A (M11533236R), 4B (M111893021R) and 4C (M113869033RE)

When the region is directly illuminated by sunlight, (Figure 5A) it is observed that there is a rock outcrop on the same area. Since the area under the rock outcrop is never illuminated by direct sunlight, the ice or any other volatiles can get entrapped and gets mixed with regolith.

This might lead to high reflectance in the NAC images (Figure 5B) under darkness when it's not illuminated by sunlight during lunar night. The same region again displays extreme reflectance in the NAC image M113869033RE (Figure 5C) when illuminated by direct sunlight. This might be due to entrapment of water ice in the rock outcrop on the Spudis crater wall in that region. (Figure 5A)

Summary: Water ice mixed with regolith might be more common in the regions where it can be trapped by rock outcrops on the crater wall as these regions never receive sunlight. These kinds of cold traps might exist on the crater walls on South Pole which might be visible in LROC NAC images because of the high reflectance at certain incidence and azimuth angles. From the above analysis, M3 Data along with Diviner, LAMP and LROC NAC Data might help us to find more such regions in which we can find more evidence of water ice on the surface of Moon. This region is close to one of the Artemis 3 landing sites.[7] and the above analysis makes it an interesting case of exploration of the region by Artemis Astronauts.

Acknowledgments LROC NAC images were used for this analysis and they were obtained from the LRO PDS Node

References: [1] Li S. et al. (2018) *PNAS* 115, 8907 [2] Hayne et al. (2015) *Icarus*, 255, 58- 69. [3] Hayne et al. (2021) *Nature*, 5, 169-175 [4] Feldman W. C. et al. (1998) *Science*, 281, 1496. [5] C. I. Honniball et al. (2020) *JGR (Planets)* 125, e06484.[6] Fisher, E.A. et al. (2017) *Icarus* 292: 74-85. [7] Artemis landing sites <https://www.nasa.gov/press-release/nasa-identifies-candidate-regions-for-landing-next-americans-on-moon>