REVISITING RADAR ANOMALOUS CRATERS IN LUNAR SOUTHERN PERMANENTLY SHADOWED REGIONS WITH SHADOWCAM. M. J. Kinczyk¹, D. B. J. Bussey², C. I. Fassett¹, B. W. Denevi¹, M. S. Robinson¹.
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Introduction: Permanently shadowed regions (PSRs) of the lunar poles have been an area of long-standing interest, given their potential to trap volatile materials and host water ice deposits [e.g., 1,2]. Indeed, identifying water ice deposits would have substantial implications for the geological evolution of, and volatile transport across, the lunar surface. Previous work investigated the radar signature of craters across the lunar poles [3,4] and found a class of craters that have a high Circular Polarization Ratio (CPR)—that is, the ratio of same-sense to opposite-sense polarization radar return—interior to the crater rim, and a low CPR exterior to the rim (Figure 1). This interior-only CPR signature was interpreted as anomalous given that fresh craters exhibit a uniformly high CPR signature across both interior and exterior due to rough, blocky materials that produce double-bounce scattering of the radar signature [5]. Additionally, [5] assumed that the high CPR signature of fresh craters (interior and exterior) should degrade uniformly over time; therefore, another mechanism must be at play to produce the high CPR signature inside these craters. Because these craters were thought to be concentrated at the poles and, in many cases, situated within PSRs, the authors interpreted that the most likely cause of the high-CPR signature was water ice due to the high volume-scattering nature of ice [e.g., 6].

Recent work has explored the radar characteristics of craters in more detail, focusing on assessing the characteristics of crater maturation and regolith development over time. One study [7] systematically assessed the radar characteristics of globally distributed impact craters 2.5-24 km in diameter. The study found that proposed anomalous craters were not concentrated at the poles as previously thought. Further, another study found that 0.8–2 km diameter craters tend to show signs of faster regolith development outside the crater versus inside the crater [8]. The difference was attributed to the greater presence of blocks on steep crater walls and the propensity of these blocks to migrate down slope, exposing new, rough surfaces for longer periods of time than the shallower-sloped exterior ejecta deposits. This process could plausibly explain the existence of craters with high CPR interiors and background-level CPR exteriors. However, the study investigated craters smaller than many of the craters proposed to be anomalous, which range from 3 km to 25 km in diameter [3,4].

Investigation: In this work, we reevaluate the classification of radar anomalous craters around the lunar south pole [3,4] using the recently reprocessed CPR data product [10] and ShadowCam image data. Original processing of the Mini-RF monostatic data corrected viewing geometry relative to the lunar ellipsoid [11] rather than to the surface topography, resulting in radar signatures strongly dependent on viewing geometry. Recent work reprocessed the Mini-RF monostatic data [10] and corrected it to the SLDEM [12], minimizing the influence of steep slopes. We additionally restricted our investigation to slopes <15°, reducing the influence of potentially rough and blocky crater walls that would elevate CPR signatures [7]. These <15° slope areas almost exclusively align with crater floors.

We first compared the interior and exterior (crater rim extending to one crater radius) CPR values for all south polar radar anomalous craters using the reprocessed CPR data product [10]. Of the radar anomalous craters previously identified [3,4], 17 of the 28 craters retained that classification. Although, many of these craters have elevated CPR values on crater walls and rims and their shallow sloped floors do not show elevated CPR values. When further filtering for slopes <15°, only 9 of the original 28 craters retained their anomalous classification.

We then inspected ShadowCam images of the floors of the remaining radar anomalous craters to identify instances of boulders and boulder fields which would
produce an elevated CPR signature. Any boulders observed in ~2 m/px ShadowCam images are likely indications of the presence of many more subpixel sized blocks [e.g., 14]. We identified boulders in four of these crater floors or near the floor-wall boundary, areas likely containing the remnants of rock slides from the crater walls. Two craters contained elevated CPR on their floors with no evidence of surficial boulders at the ShadowCam pixel scale (~2 m/px) (e.g., Figure 2). Four craters either did not have ShadowCam image coverage or were too dark even under secondary illumination. Further examination of these craters will be conducted if ShadowCam can acquire images during more favorable secondary illumination conditions.

**Conclusion:** Inspection of the new incidence angle-corrected CPR data product [10] reveals that elevated CPR values within craters classified as radar anomalous are most likely to occur on crater walls and rims. Elevated CPR values in low-slope crater floors with no evidence of surface boulders could be due to the presence of subsurface boulders that have subsequently been buried by regolith. Since the Mini-RF monostatic signal can penetrate several meters into the lunar surface and is sensitive to <m-sized blocks [15], the lack of identifiable surficial boulders (~4 m in diameter for confident detection in ShadowCam images) in areas with elevated CPR does not rule out the presence of subpixel sized blocks or boulders/blocks at depth.

We are currently expanding this work to include the evaluation of radar anomalous craters in northern PSRs as well as a number of non-anomalous craters using the same methods. While this work does not rule out the presence of volatiles within proposed radar anomalous craters or other potential cold traps at the lunar poles, we do not find strong evidence that the radar signatures of the studied craters are related to ice. More work is needed to disentangle the multiple regolith characteristics that produce elevated CPR signatures and their application to the Moon.

**References:**