HETEROGENEITIES IN COMPOSITION AND BURIAL DEPTH OF THE LUNAR SCHILLER-SCHICKARD CRYPTOMARE. A. M. Bramson[1,2], L. M. Carter[1], G. W. Patterson[3], L. M. Jozwiak[3], G. A. Morgan[4], M. M. Sori[1,2], C. A. Nypaver[5], and J. T. S. Cahill[3]. [1]University of Arizona, Lunar and Planetary Laboratory, [2]Purdue University, Department of Earth, Atmospheric, and Planetary Science, [3]Johns Hopkins University Applied Physics Laboratory, [4]Planetary Science Institute, [5]University of Tennessee. (Corresponding author: bramsona@purdue.edu)

Introduction: Quantifying the volumes and character of lunar volcanic eruptions is important for constraining the thermal and geologic evolution of the Moon. Effusive, lunar basaltic lava flows ("maria") that were subsequently buried by higher-albedo basin/crater ejecta are called cryptomaria (e.g., [1]). Radar, with its centimeters-to-meters wavelengths, offers the ability to probe the subsurface for geologic units, such as cryptomare, at depth ranges intermediate between that sensed by spectroscopy (nanometers) and gravity (100s of m).

Bistatic 70-cm wavelength (430 MHz; "P-band") radar data from Arecibo Observatory and Green Bank Observatory were used by [2] to survey for cryptomare east of Orientale basin (0°–45°S, 55°–105°W). These deposits were detected based on their low radar returns, as the higher ilmenite (TiO_2) content often present in mare lava flows can attenuate radar returns significantly. The observations show that the low-radar-return lava flows extend beyond the area of mare evident at the surface, throughout much of the region between Cruger and Oceanus Procellarum, as well as some patches northwest of Humorum basin. These flows cover an area of 178×10^3 km^2, are buried by up to tens of meters of highlands ejecta material, and represented a 2.7% increase in the areal coverage of known lunar mare basalts [2].

The Schiller-Schickard region is one of the most established cryptomare locations due to a combination of spectral mixing analyses [3–5], optical dark halo craters [6–8], and gravity signatures [9]. Here, we build upon the results of [2] to map the radar returns/backscatter across the Schiller-Schickard region (30°–60°S, 40°–70°W), southeast of Orientale, and compare our radar-based "units" to previous maps of cryptomare [8], surface mare [10], and light plains units [11].

Methods: We used the bistatic Arecibo Observatory/Green Bank Telescope depolarized backscatter P-band radar images to qualitatively map the Schiller-Schickard region into five radar "units" from "darkest" (lowest returns) to "brightest" (highest returns), (Fig. 1). We calculated the average backscatter value in each of these five units (Fig. 2), which confirmed quantitatively the pattern in backscatter returns for the five units.

Assuming that the depolarized radar values vary due to the burial depth of the lava flows (e.g., that the lava flows themselves are all of the same composition containing high TiO_2), we modeled the thicknesses of the ejecta coating over the units we mapped, following the methodology in [2]. We assumed that the brightest radar unit we mapped was most representative of ejecta materials and that the loss tangent of highlands ejecta is 0.001. We also made the same calculations for each unit based on the monostatic depolarized S-band (12.6 cm; 2380 MHz) signal from the Mini-RF instrument onboard NASA's Lunar Reconnaissance Orbiter (LRO). The wavelengths of the two datasets differ vary by a factor of ~6, so comparing them illuminates differences in the shallow subsurface structure.

Results: We find that the units associated with the lowest depolarized radar returns are in areas with known surface mare and/or areas with highest surface TiO_2 content (from [12]). This is not surprising due to the attenuating nature of ilmenite at radar wavelengths. However, there are often distinct radar boundaries that do not follow previously-mapped boundaries based upon surface geology and spectroscopic signatures [8,10,11]. In some places, the S-band and P-band signatures differ from each other as well, though a similar trend in average backscatter values suggests they are mostly detecting similar units (though with increased scattering in the S-band caused by cm-scale blocky crater ejecta).

Evidence for cryptomare is often restricted to the coincidence of having a crater sufficiently large to have excavated through the overlying highland material to the underlying lava flow. Radar allows us to track mare lava flows from the surface into the subsurface, and we find that the cryptomare are likely buried by tens of meters of ejecta for the brighter radar units and a few meters for the darker radar units, which often contain regions mapped as surface mare (Fig. 2).

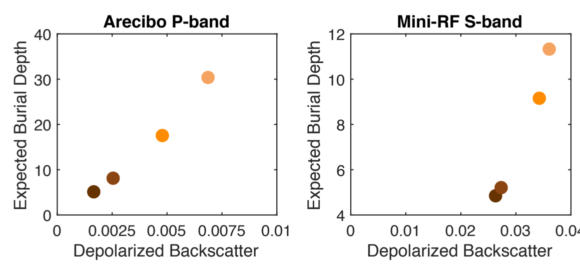

Figure 2. *Burial depths modeled for the four darkest P-band radar units versus the average depolarized signal in P-band (left) and S-band (right) within these units. We assume the fifth (brightest) unit represents radar-bright ejecta with no mare and so is not plotted here.*

Conclusions: We find that our mapped radar units frequently do not correspond to previously mapped mare/cryptomare units in the Schiller-Schickard region. We propose that much of this variation can be attributed to heterogeneities in the thickness of ejecta that covers the lava flows. However, ejecta burial is not the only process that can contribute to variations in radar brightness; surface mare exhibit multiple flow episodes of variable ilmenite (TiO_2) amounts that have been mapped in radar [13]. Therefore, it is likely that some of the spatial boundaries we see in the radar data are due not only to burial by brighter ejecta/light plains material of varying thickness, but also to different flow units and compositions within the eruptions that formed the cryptomare across Schiller-Schickard. We conclude that the region likely contains a complex network of lava flows buried under a complex structure of ejecta of variable-thickness, and caution against a binary interpretation of the presence/absence of either mare or cryptomare.

Future Work: We are currently targeting the Schiller-Schickard region with Mini-RF to increase the bistatic Mini-RF coverage, fill in the spatial gaps in this dataset, compare data in different wavelengths to help unravel the subsurface structure, and understand the role layered subsurfaces play on radar signals.

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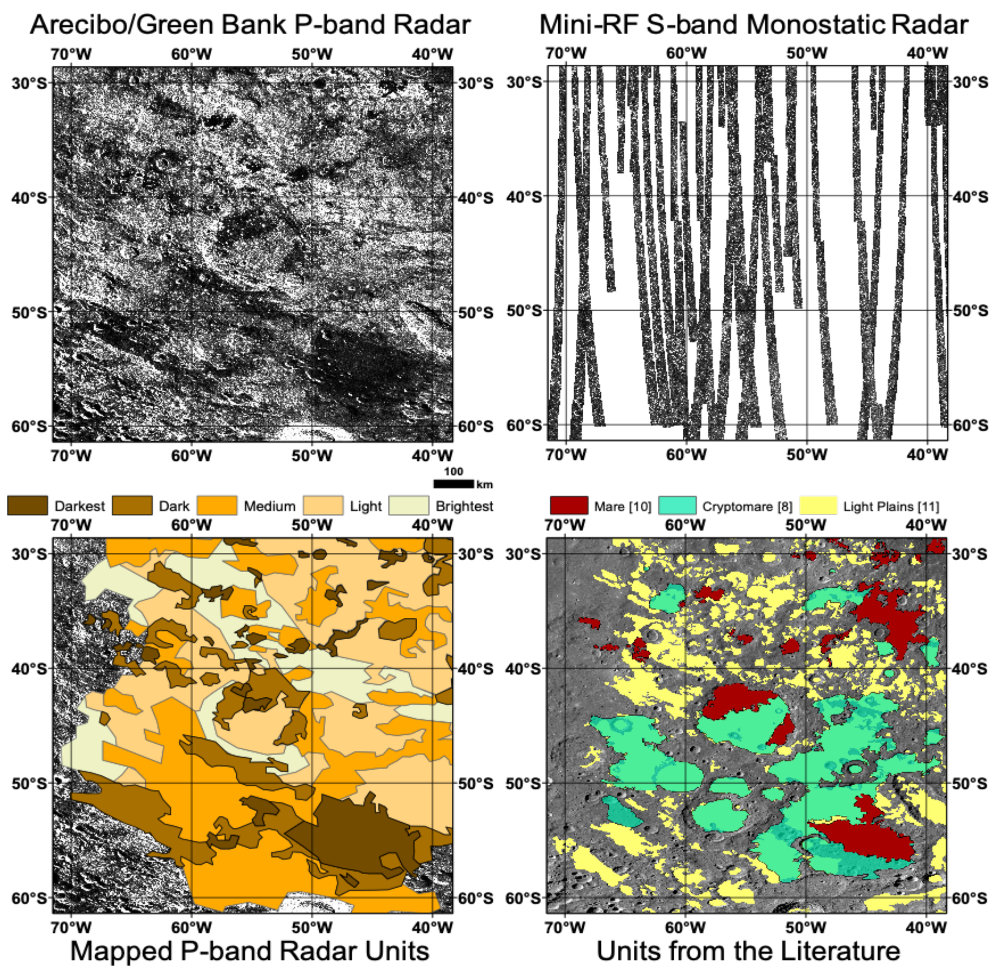

Figure 1. *Maps of the Schiller-Schickard region. Top: Depolarized radar data from Arecibo/Green Bank (left; P-band) and Mini-RF (right; S-band). Bottom-left: P-band radar units mapped in this work. Bottom-right: Units across the region previously mapped in the literature.*