MINI-RF S-BAND RADAR CHARACTERIZATION OF A TYCHO RAY OVER THE LUNAR SOUTH POLE.
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Introduction: Using Arecibo S-band (12.6 cm, 2380 MHz) bistatic data, [1] identified clusters of small craters within the floors of Newton (76.7°S, 16.9°W) and Newton-A (79.7°S, 19.7°W) that were characterized by high circular polarization ratios (CPR) in an asymmetric, tear drop shape pattern. Because the heightened wavelength-scale roughness feature extends downrange from Tycho, these craters were interpreted as its secondaries. Indeed, [2] later identified a Tycho pole-crossing ray in LOLA reflectance data that coincided with the location of these putative secondaries and that extends, at least, past de Gerlache and Shackleton craters.

Identification of lunar secondaries helps to refine interpretations of surface ages, and informs our understanding of the inner Solar System bombardment history by removing their contamination from primary crater counts. Furthermore, in light of the Artemis III program, identification of secondaries and their prominence can help contextualize landing site selection. Thus, here we further the characterization of the pole-crossing Tycho ray using S-band observations from the Lunar Reconnaissance Orbiter's (LRO) Miniature Radio Frequency (Mini-RF) instrument.

Observations: Mini-RF is a hybrid-polarimetric, synthetic aperture radar designed to record the full polarization state of received backscatter, described by the Stokes parameters. To characterize the Tycho ray, we used controlled polar mosaics of each Stokes parameter, which allows for the formation of several child products, such as CPR, which is the ratio of the same-circular (SC) and opposite circular (OC) polarizations relative to transmit, as well as decomposition products, which break radar backscatter into different scattering components [3]. The mosaics are calibrated, monostatic radar products formed from data over multiple acquisitions, and thus are products averaged over a range of local radar incidence angles.

Identification: In Fig. 1, we show a map of OC radar backscatter. As annotated in the figure, the Tycho ray is faintly visible. It can be seen transecting Newton, G, A, and B craters. From Newton to Haworth crater, it is a well-defined 15 km wide radar bright feature whose location agrees with the heightened LOLA reflectance albedo feature [2]. We found that the ray likely extends ~1600 km away from Tycho because the last recognizable cluster of secondaries are seen near Wiechert J crater (85.6°S, 177.0 °W).

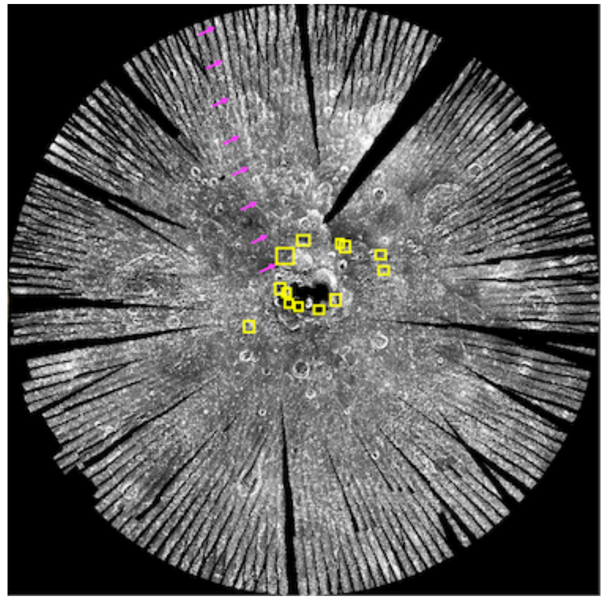

Figure 1: Mini-RF OC radar mosaic of the south pole (>70°S) averaged over both look directions. The magenta arrows point to the Tycho ray. Yellow boxes indicate candidate Artemis III landing sites. OC backscatter intensity is in gray scale.

Characterization: Although the ray is a radar bright feature in OC and SC, it is not a heightened CPR feature. Indeed, the average CPR of the region is 0.46±0.04, which is indicative of typical lunar wavelength-scale complexity. However, CPR is a zeroth-order approximation of "roughness" and recent work has argued for analysis of each polarization separately [4]. In their work, [4] found that the inverse of the slope of the least-squares fit (LSF) line to SC vs OC of a unit describes scatterer complexity. By binning data longitudinally along the ray in small steps of 10 km, we found that the inverse of the SC vs OC slope significantly decreases with distance away from Tycho, which implies there is a decrease in wavelength-scale scatterers and/or morphologically complex scatterers with distance from Tycho. Additionally, we found that the ray is characterized by enhanced odd bounce and volume scattering in an m-χ decomposition, but lacks a significant even bounce signature. Thus, taken together the ray is likely an area of increased roughness from ejected, decimeter-scale fragmental material that only reworked the top, mature lunar regolith.

References: [1] Wells, K. S. et al. (2010) JGR 115, E06008. [2] Denevi, B. W. and Robinson, M. S. (2020) LSSW, Abstract #5122. [3] Raney, R. K. et al. (2012) JGR 117. [4] Virkki, A. K. & Bhiravarasu, S. S. (2019) JGR 124.