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A Novel Radar Processing Tool for Estimating the Permittivity Profile of the Shallow Lunar Ejecta: A Case Study at the Von Kármán Crater

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On 3rd of January 2019, the Lunar probe Chang'E-4 landed at Von Kármán (VK) crater at South-Pole Aitken (SPA) crater. The transient cavity of SPA has been estimated at 840-1400 km, which implies that the SPA basin excavated through the Lunar's crust and into the mantle. Due to that, the geology of the area has attracted a lot of interest, since mantle materials can provide useful insights on the mineralogical composition of the upper mantle and the formation of the Moon.

Lunar Penetrating Radar (LPR) has been applied for both satellite and in situ measurement configurations resulting to fruitful insights regarding the dielectric structure of the Moon. The Yutu-2 rover from the Chang'E-4 mission is equipped with a low-frequency (60 MHz) and two high-frequency (500 MHz) antennas. Previous research [1] using the high-frequency data from the Yutu-2 rover, concluded that a homogenous ~12 m weathered layered overlays the ejecta from the near-by Finsen crater. This model is based on typical hyperbola-fitting and the lack of layers on the measured radagram for the first ~150 ns [1].

Typical hyperbola-fitting is not suitable for complex media with varying permittivity with depth. To mitigate that, we propose a novel interpretation tool that fits multiple hyperbolas simultaneously by estimating the optimum one-dimensional permittivity profile. The suggested scheme is successfully validated via a series of numerical experiments and subsequently applied to the data acquired by the Yutu-2 rover during the first two Lunar days of the mission. Four distinct layers were identified in the first ~12 m that were previously non-visible due to their smooth dielectric boundaries. This differs from previous results [1] where the first ~12 m are assumed homogeneous, part of the weathered fine-grained regolith of the Finsen crater. Based on these results, we suggest a new stratigraphic model in which the ejecta of VK L' (~ 5.5 m) were deposited on top of the Finsen ejecta. Space weathering degraded the first ~1.5 m of the ejecta decreasing its density and electric permittivity. The ejecta from VK L were subsequently deposited on top of the weathered layer creating a top layer with ~6 m width. The long weathering process, from early Eratosthenian till now, gave rise to a ~3 m of loose Lunar soil with low electric permittivity. The suggested model is consisted with the LROC NAC images [2], the expected Lunar weathering rates

[3] and the mineralogical content of the area [2].

References

[1] Zhang, L., Li, J., Zeng, Z., Xu, Y., Liu, C., & Chen, S, (2020), Stratigraphy of the Von Kármán crater based on Chang'E-4 lunar penetrating radar data. Geophysical Research Letters, 47.

[2] Huang, J., Xiao, Z., Flahaut, J., Martinot, M., Head, J., Xiao, X., & et al. (2018), Geological characteristics of Von Kármán crater, northwestern South Pole-Aitken basin: Chang'E-4 landing site region, Journal of Geophysical Research: Planets, 123, 1684-1700.

[3] Gou, S., Yue, Z., Di, K., Cai, Z., Liu, Z., & Niu, S. (2021), Absolute model age of Lunar Finsen crater and geologic implications, Icarus, 354, 114046.