Layered structures in the upper several hundred meters of the Moon along the Chang'E-4 rover's traverse. J. Feng and M. Siegler, Planetary Science Institute

In 2019, the Chang'E-4 (CE-4) spacecraft landed at 45.456°S, 177.588°E, on the eastern floor of Von Kármán crater in the South Pole-Aitken (SPA) basin on the Moon's far side. The floor of Von Kármán crater was flooded by mare basalt during the Imbrian age. Several nearby younger large (>25 km) impact craters might contribute massive ejecta materials to the surface regolith in the Von Kármán. The CE-4 mission provides a valuable opportunity to detect the ejecta thickness as well as the scale of basalt eruption in this crater, with a ground penetrating radar instrument on the Yutu-2 rover—the Lunar Penetrating Radar (LPR). The LPR sends EM pulses into the lunar subsurface, and these radar signals will be reflected and received by antennas if they hit vertical dielectric contrast between two different media. Therefore, The LPR can discern the layers in the regolith, buried rocks, and the boundaries between regolith and bedrock in an accurate way. From January 2019 to October 2021, the Yutu-2 rover drove ~860 m.

There has been a debate about the interpretation of LPR low-frequency data. Li et al. [1] state that the deep radar echoes in CE-3 LPR data previously ascribed to the lunar shallow stratigraphy by Xiao et al. [2] are artifacts caused by antenna coupling with the rover and the lunar surface. They found that the same signals were also present in ground test data at the same time depth and with the same frequency spectrum characteristics. By processing the CE-4 LPR data in different ways, Zhang et al. [3], Lai et al. [4], Yuan et al. [5], and Zhang et al. [6] recognized a variety of subsurface layers separately and gave their geologic explanations. However, Pettinelli et al. [7] argued that system noise had been misinterpreted as a natural sequence of reflectors so the stratigraphic interpretation of the low-frequency data does not have any physical meaning. This debate comes from the fact that the data analyzed in previous studies were collected during the first several lunar days. The distance traveled by the rover at that time was short, so the subsurface reflectors might not have had enough topographic variation, leading to horizontal flat bands that are difficult to distinguish with system residual response in the radargram. Utilizing the large amount of data taken since that time, here we conduct new investigations of the geologic structure at the landing site in a more reliable way.

We applied regular processing algorithms widely used in GPR [8] to the LRP CH1 data, including resampling, bandpass filtering, time-zero correction, and exponential gain compensation (SEC). The radar image of CH1 after data processing is given in Figure 1. The CH1 reached a depth of ~ 200-300 m. Our results generally agree with the previous studies [3-6], but with more layers accurately identified. The structure preserves a series of basalt eruption events in the Von Kármán crater.

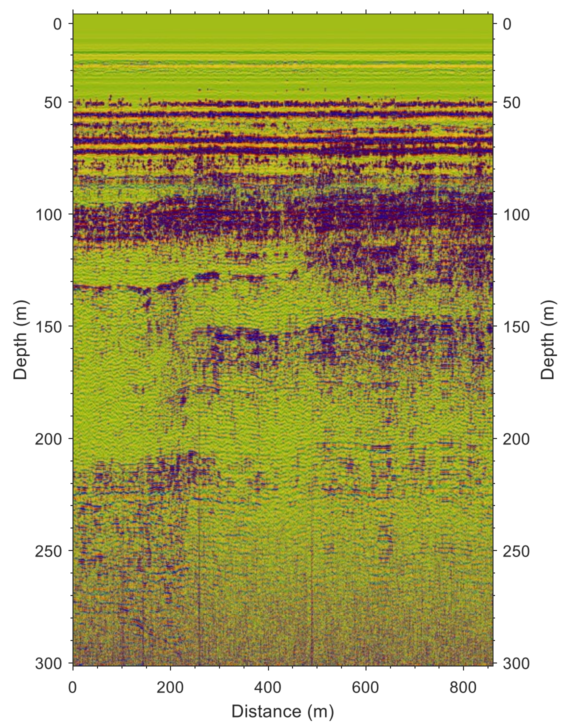

Figure.1 CH1 radargram after data processing, showing a layered structure down to ~250-300 meters

References:

[1] Li, C. et al. (2017) *IEEE TGRS*, 56, 1325-1335. [2] Xiao, L. et al. (2015) *Science*, 347, 1226-1229. [3] Zhang, J. et al. (2021) *Nature Astronomy*, 5, 25-30. [4] Lai, J. et al. (2020) *Nature communications*, 11(1), 1-9. [5] Yuan, Y. et al. (2021) *EPSL*, 569, 117062. [6] Zhang, L. et al. (2020) GRL, 47, e2020GL088680. [7] Pettinelli, E. et al. (2021) *Nature Astronomy*, 5, 890-893. [8] Jol, H. et al. (2008). *Ground penetrating radar theory and applications*: Elsevier.