Geophysical Research Abstracts
Vol. 17, EGU2015-4282, 2015
EGU General Assembly 2015

Data Processing and Primary results of Lunar Penetrating Radar on Board the Chinese Yutu Rover

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Radar is an attractive and powerful technique to observe the Moon. Radar mapping of the Moon's topography was first done by the Arecibo telescope at a wave- length of 70 cm in 1964 (Thompson & Dyce 1966). Chang'e-3 (CE-3) was successfully launched on 2013 December 2, and the landing place is in Mare Imbrium, about 40km south of the 6km diameter Laplace F crater, at 44.1214ON, 19.5116OW. The Lunar ground-Penetrating Radar (LPR) is one of scientific payloads of the Yutu rover, aiming to achieve the first direct measurements and explore the lunar subsurface structure. Compared with ALSE and LRS, LPR works at higher frequencies of 60 MHz and 500 MHz. Thus it can probe regions with shallower depth including the regolith and lunar crust at higher range resolution.

The LPR uses one transmitting and one receiving dipole antenna for 60 MHz which are installed at the back of the rover. For 500 MHz, one transmitting and two bow-tie receiving antennas are attached to the bottom of the rover. It transmits a pulsed signal and receives the radar echo signal along the path that the Yutu rover traverses. The free space range resolutions are $\sim$ 50 cm and $\sim$ 25 m for 60 MHz and 500 MHz respectively. The radar data stop being sampled and are sent back to Earth when Yutu is stationary. Observations are simultaneously carried out at frequencies of 60 MHz and 500 MHz. Since the Yutu rover had severe problems during its second lunar day, it is pity that the Yutu rover only transversed a limited distance of 114.8m. In total, 566 MB of data were obtained.

The scientific data are archived and distributed by National Astronomical Observatories, Chinese Academy of Sciences. Data processing has been done in order to eliminate the effect of the instrument. To obtain clear radar images, more data processing need to be applied such as coordinate transformation, data editing, background removal, the operations of smoothing and gain resetting. The radar signal could detect hundreds of meters deep at 60MHz and tens of meters at 500MHz. Based on the previous lunar subsurface research and Apollo samples analysis, the dielectric constantεr of the lunar rock is set to be 7 and the dielectric constantεr of the lunar regolith is set to be 3.1 The LPR observations reveal that Mare Imbrium has subsurface stratifications. The regolith is not uniform and structures with multiple layers have been observed. The results indicate the thickness of the regolith is 4–6 m. The typical hyperbolic shapes that might be caused by rocks underneath the regolith have been found. Furthermore, several prominent reflective layers at depths of hundreds of meters have been clearly derived. The buried regolith layer might have been accumulated during the depositional hiatus of mare basalts.