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TOPOGRAPHIC MAPPING AND ANALYSIS AT THE LANDING SITE OF CHANG'E-3 ON THE MOON

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ABSTRACT:

The Chinese lunar probe Chang'E-3 carrying the "Jade Rabbit" lunar rover successfully landed in the Sinus Iridum area of the Moon on December 14, 2013. Funded by China Academy of Space Technology (CAST), we have been working on a project of lunar topographic mapping and analysis of the landing site area since August 2012. This paper summarizes the developed innovative lunar topographic mapping and analysis techniques and the generated products in this project.

To ensure a safe and successful landing a careful analysis of topography and geomorphology of the landing area has to be carried out. This is comprised of identifying favourable target areas and evaluating the surface conditions in these areas. Features like slopes, craters and boulders have to be identified in order to assess the risk associated to a landing site in terms of a successful touchdown and subsequent surface operation of the lander and rover. Requested by CAST, we mapped and analysed the topography of the candidate landing area of Chang'E-3 using multi-source lunar remote sensing data collected by different sensors from different missions.

We firstly examined a large area from 15°W-40°W, 20°N-50°N, where Sinus Iridum is located in the upper part of this area. Chang'E-1 imagery (120 m/pixel resolution), Chang'E-2 imagery (7 m/pixel resolution), and the LRO's Lunar Orbiter Laser Altimeter (LOLA) data were used to map the area. Digital elevation models (DEMs), contour maps, and orthophotos were generated in this area. Slope analysis was carried out based on the generated topographic models in this area, and slop maps and statistics of slops were generated and analysed. The results were used to understand the general situation of the topography in this area.

The Sinus Iridum area (18.2°W-34.6°W, 42.6°N-45.6°N) as previously identified as the candidate landing area of Chang'E-3 was then investigated in detail. 15 strips of Chang'E-2 imagery (7 m/pixel resolution) and the corresponding LOLA data were employed in this investigation. An innovative method for integrating cross-mission and cross-sensor data sets for precision lunar topographic mapping through a combined block adjustment was developed for the integrated process of Chang'E-2 imagery and LOLA data. DEMs with 20 m resolution and orthophotos with 7 m/pixel resolution were generated for this area. Slope analysis was carried out based on the DEMs, and slop maps and statistics of slops were generated and analysed. Results reveal that majority of this area is relatively flat. The average slop is 1.7°, and 86.99% of this area has slops less than 2°. Large slopes are concentrated around the craters. The slops for some crater walls exceed 20°. To analyse the distributions of craters in this area, we developed a semi-automatic method for crater detection by integrating image processing techniques and DEM-based surface analysis. 18914 craters with diameters greater than 50 m were extracted in this area, and statistical analysis found that 87.86% of them have a depth/diameter ratio less than 0.11 and 96.05% of them have a rim height/diameter ratio less than 0.06.

To further investigate the topographic details, three sub-regions located in the central and right part of the Sinus Iridum area with representative surface conditions were selected for further detailed analysis. The LRO narrow-angle camera (NAC) imagery (1.5 m/pixel resolution) and the Chang'E-2 imagery (1.5 m/pixel resolution) as well as the corresponding LOLA data were used. Similar topographic mapping using these data sets was carried out, and DEMs with 4.5 m resolution and orthophotos with 1.5 m/pixel resolution were generated in these sub-regions. Similar slope analyses were carried out in these regions and the slop statistics vary among these regions, but they are generally consistent with the slop statistics for the entire Sinus Iridum area as mentioned above. Crater detection and analysis were also carried out in these regions. Craters with diameters greater than 10 m were extracted, and statistical analysis revealed similar results with the crater statistics in the entire Sinus Iridum area as mentioned above. It was also found that the cumulative crater distribution for craters with diameters greater than 10 m in these three regions is about 1/10 of the theoretic cumulative crater distribution (NASA, 1969).

The above described lunar mapping and analysis techniques and the generated topographic products were used in the topographical analysis and identification of the landing site of the Chang'E-3 mission, making a useful contribution to the success of the Chang'E-3 mission.