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Apollo 17 Landing Site: A Cartographic Investigation of the Taurus-Littrow Valley Based on LROC NAC Imagery

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Abstract

A Digital Terrain Model (DTM) of the Taurus-Littrow Valley with a 1.5 m/pixel resolution was derived from high resolution stereo images of the Lunar Reconnaissance Orbiter Narrow Angle Camera (LROC NAC) [1]. It was used to create a controlled LROC NAC ortho-mosaic with a pixel size of 0.5 m on the ground. Covering the entire Apollo 17 exploration site, it allows for determining accurate astronaut and surface feature positions along the astronauts' traverses when integrating historic Apollo surface photography to our analysis.

1. Introduction

Previously we reported on our cartographic investigations of the Apollo 17 landing site area based on 0.25-0.5 m/pixel scaled LROC NAC ortho-image maps. In our former studies we concentrated on the area in close proximity to the Lunar Module (LM). By combining Apollo surface photography and LROC NAC ortho-images, we were able to map positions of astronauts and equipment [2] as well as the Geophysical Stations that were part of the active seismic experiment of the Apollo Lunar Surface Experiment Package (ALSEP) [4]. The production of a new LROC NAC DTM covering the entire region explored by the astronauts during their three days lasting stay on the lunar surface, allows us to expand our cartographic investigations of the Apollo 17 landing site. A grid spacing of 1.5 m/pixel for the DTM and 0.5 m/pixel for a controlled ortho-mosaic, respectively, were chosen.

2. Stereo Image based DTM

We used five LROC NAC stereo pairs with image resolutions of 0.5-1.5 m/pixel to process a high resolution DTM (1.5 m) covering the entire (see Figure 1). For stereo image processing the LROC-adapted DLR photogrammetric processing chain [4] was used, integrating the most current camera position and pointing information, i.e. GRAIL refined ephemeris data [5] as well as temperature corrected LROC geometry [6]. To be consistent with the Lunar Laser Ranging (LLR) frame we chose to laterally tie the DTM to the Mean Earth/Polar Axis (ME)-coordinates of the LM given by [7]. For vertical geodetic control we co-registered the DTM to the available Lunar Orbiter Laser Altimeter (LOLA) tracks crossing this area by applying least squares adjustment techniques [8].

3. Controlled Ortho-Mosaic

For the generation of a 0.5 m/pixel scale ortho-mosaic of the landing site we chose 12 LROC NAC images acquired from seven different orbits (1202, 2767, 5026, 5375, 7633, 9545, and 9892). Because of differences in orbit altitudes, their ground sampling distances range from 0.25 m to 0.5 m. Their incidence angles vary from 22° to 69° and they all share similar lighting conditions, i.e. the sun shines from the west (sub solar azimuth: ~200°). By applying the 1.5 m-DTM all images were ortho-rectified and map projected on a sphere. To preserve angles and to keep distortions reasonably small, we chose the Transversal Mercator projection with true scale at the central meridian (30.7° E). The ortho-images were mosaicked followed by a co-registration to the lunar-fixed ME-coordinate system. For this, we used the ALSEP's central station, which could be identified in the images, as ground control point with the coordinates given by [7].

4. Astronaut Positioning

Apollo Hasselblad images are used in combination with the LROC NAC ortho-mosaic to determine accurate lunar-fixed ME-coordinates of the astronauts' positions from where they took panoramic images. A weighted least squares adjustment is applied to fit a network of angular directions measured in digitized Hasselblad frames to a set of reference points, that are observed in the LROC ortho-map. The center of the adjusted network constitutes the Hasselblad's position at the time of image acquisition.

5. Outlook

We are going to present our current results of accurate ME-coordinates of the Apollo 17 Traverse Stations as well as our work towards a new *Apollo 17 Traverse Map* (1:15,000). Furthermore, to support the ongoing re-analysis of the Apollo seismic data [9], we will present improved coordinates of the four Explosive Charges (EPs) located at further distances from the LM (EP-1, -5, -6, and -7).

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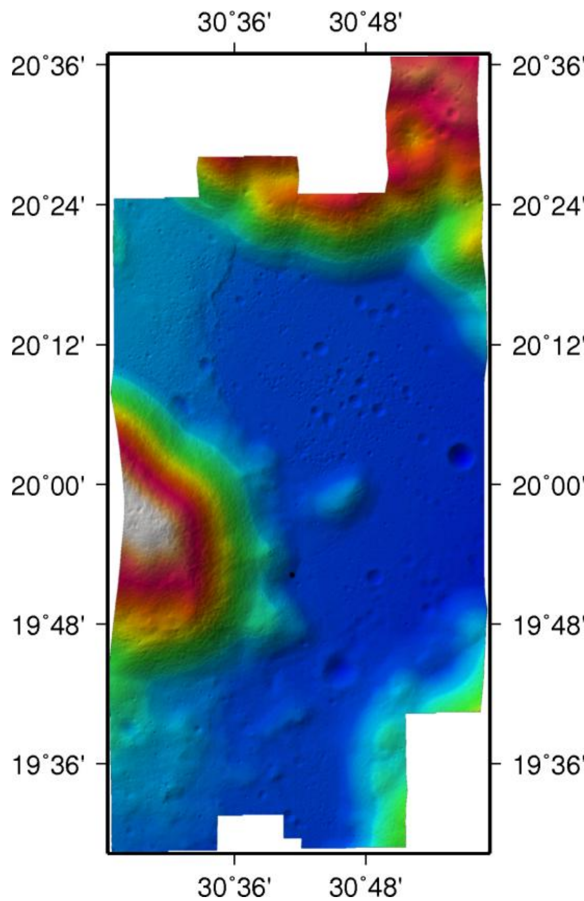

Figure 1: LROC NAC based 1.5-m/pixel-DTM of the Taurus-Littrow Valley. Heights are color-coded and hill-shaded and refer to a mean lunar sphere (R = 1737.4 km).