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Morphometric analysis of Linné crater and relations with numerical modelling

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Abstract

Morphometric analyses, applied to high resolution DTMs, allowed us to enhance the morphologic variations occurring in crater inner scarp. This specific analysis on surface topography, applied to the case study of Linné, was able to emphasize and possibly confirm the presence of different stratigraphic layers at the Linné site.

1. Introduction

Linné is a well preserved impact crater of 2.2 km in diameter, located at 27.7°N 11.8°E, near the western edge of *Mare Serenitatis* on the Moon. The crater was photographed by the Lunar Orbiter and the Apollo space missions, and therefore has served as most striking example of small fresh simple craters with its characteristics bowl shape. However, recent high resolution data of Lunar Reconnaissance Orbiter Camera (LROC) has revealed that Linné is an inverted truncated cone [1].

2. Morphometric analysis

In this study we have applied 3D morphometric analysis on high resolution DTMs, derived from LROC Narrow Angle Camera (NAC) that provide a resolution range from 0.5 to 2 m/pixel. This analysis was carried out by processing the Linné crater DTM, with a cell size of 2m/px. Firstly, we applied a multiscalar approach [2], to reduce DTM building and interpolation errors aiming to find the best compromise of a smoothed DTM without losing the topographic relevance of the smaller landforms. To this regards, we tested different kernel sizes, ranging from 3x3 to 99x99, in order to evaluate the best window size to calculate morphometric variables such as slope (first derivative) and curvatures (second derivative), useful to characterize the different sectors of the crater (rim crest, floor, slopes and related boundaries). From the statistics of expression of multiscale morphometric analysis we were able to establish that the best windows size for this DTM is around 66m.

3. Morphometric signature of Linné crater

The statistical analysis of slope and curvature values allowed us to characterize the morphometric signature of Linné crater.
Firstly we subdivided the crater in four morphologic sectors: floor, inner scarp, rim and external scarp.
The floor presents a mean slope gradient of 0°-3° with a profile curvature of 0.05°; those values are typical of a flat floor, confirming the freshness of Linné. For the inner scarp the mean slope gradient is 31.2°, consistently with the lunar regolith angle of repose (31°), whereas the mean profile curvature is 0.1°, slightly convex (> 0).
The most interesting result derives from the rim sector that presents a mean profile curvature of 0.5° (convex morphology), with a slim top area with about 0° of profile curvature and 0° of slope, revealing the presence of a pristine crest: this kind of feature is characteristic of a very fresh crater.
On the external scarp the mean slope gradient is about 10° and the profile curvature is negative (-0.05°), defining a slightly concave morphology.

4. Analysis of the Linné inner scarp

The slope map classification enhanced a clear cut boundary within the inner scarp of the crater, at a depth of about 200-300 m, also identified on the topographic profile, as a bland morphological step on the inner crater scarp. This feature was firstly hypothesized through numerical investigation [3] and can be explained as the transition between two different geological units, as shown by the numerical model. The model is based on a projectile of 40 m in

radius impacting at 18 km/s into a 2-layered target, with the upper layer made of fractured material of variable thickness. We found that the non-bowl-shape morphology of Linné may be ascribed to the transition from an upper 200 m highly fractured layer to a lower more competent one (FIG-2B) [3].
Moreover from the classification of the profile curvature we detected other two morphologic layers, between the first feature and the rim crest. Those layers are imperceptible on the topographic profile and on the orthoimage, making morphometric analysis a useful and valuable tool to detect and quantify crater morphologic features.

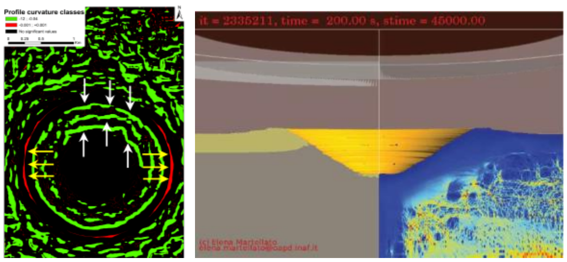

Figure 1: *left*: profile curvature classified to enhance the rim crest (red) and morphological steps in the inner scarp; *right*: numerical modelling of the Linné crater [3].

5. Summary and Conclusions

This research shows how morphometric analysis can be useful to detect and quantify the morphology of impact craters. The extraction of pixel values, from different morphometric variables, enable us to calculate surface statistics, in order to quantify different sectors of an impact crater. Moreover, morphometric analysis allowed us to detect and measure morphological layers within Linné crater, which can be associated to numerical investigations [3]. This analysis is only a part of a more extensive project, aimed to estimate the degradation evolution of simple impact craters. We are extracting morphometric variables from several impact craters in *Mare Serenitatis*, in order to quantify the degradation of the different sectors of craters.

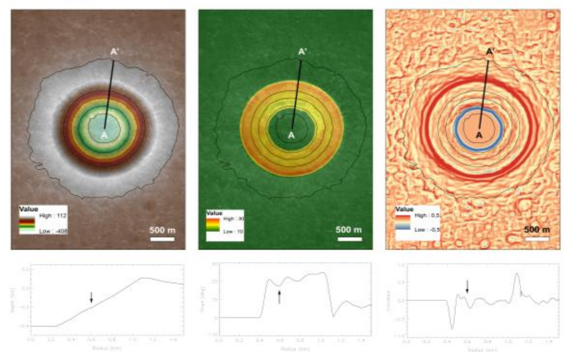

Figure 2: *left*: topographic map of Linné crater, with the relative topographic profile A-A'; *center*: slope map, which enhances the inner scarp and the floor, with the relative slope profile along the A-A' segment; *right*: profile curvature, which enhances the rim (red) and the morphological steps in the crater inner slope. The arrows on each profile indicate the location of the morphological step.

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