MORPHOMETRIC ANALYSIS OF A FRESH SIMPLE CRATER ON THE MOON

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INTRODUCTION

Linné is a well preserved impact crater of 2.2 km in diameter and 0.6 km in depth, located at 27.7°N 11.8°E, near the western edge of Mare Serenitatis on the Moon (Fig 3). Since the Fifties, more than once the crater was photographed by the NASA missions Lunar Orbiter and Apollos, and therefore has served as the most striking example of small fresh simple craters.

NUMERICAL INVESTIGATION

The numerical investigation is performed through iSALE shock physics code. Initially developed by [1], the code has been enhanced through modifications which include an elasto-plastic constitutive model, fragmentation models, various equations of state (EoS), multiple materials, a novel porosity compaction model, the ε-α-model [2, 3, 5, 6]. In addition, the code is well tested against laboratory experiments at low and high strain-rates [6] and other hydrocodes [7].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. 1A) [4].The model was derived from the best fit with the DTM (Fig. 1B).

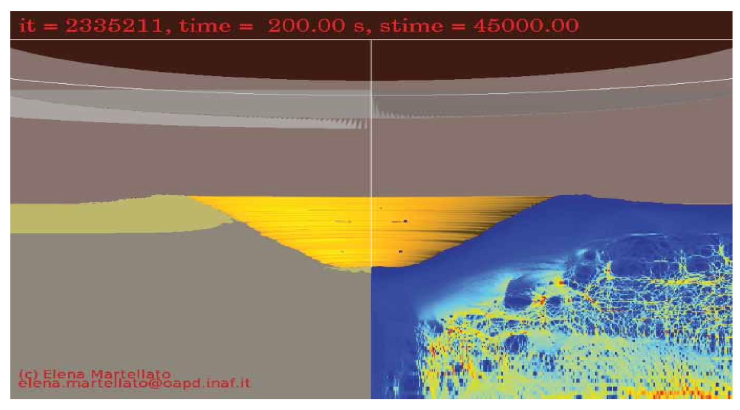

FIG 1A - Snaphot of the final modeled crater: the left side shows the different material types involved in the simulation; the rigth side shows pressure contours in a color scale (increasing scale of pressures from blue to red).

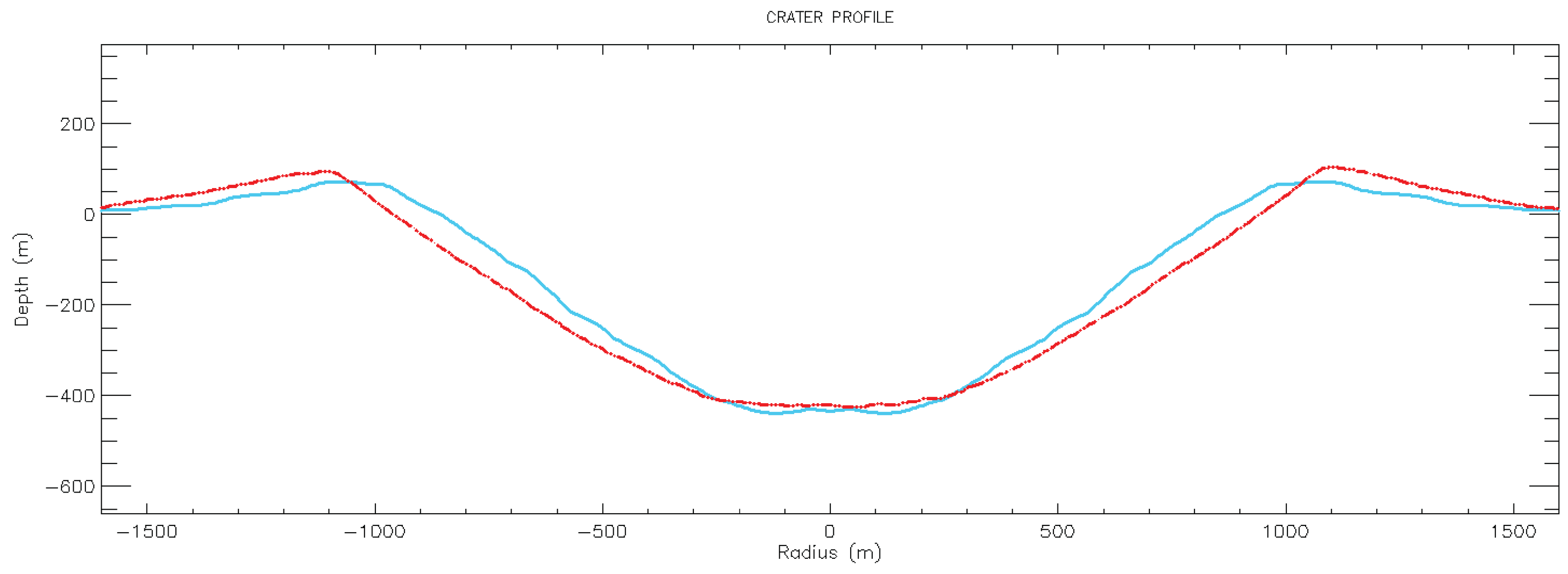

FIG 1B - Comparison between the DTM (red profile - Garvin et al., 2011) and the iSALE output (pale blue) profiles

DATA

We analyzed DTMs from:

- LROC NAC(1), with a resolution ranging from 0.5 to 1.5 m/pixel.

- LROC WAC(2), that is providing a global lunar surface coverage with a resolution of about 100 meters/pixel.

(1) = Lunar Reconnaissance Orbiter Camera, Narrow Angle Camera.
(2) = Lunar Reconnaissance Orbiter Camera, Wide Angle Camera.

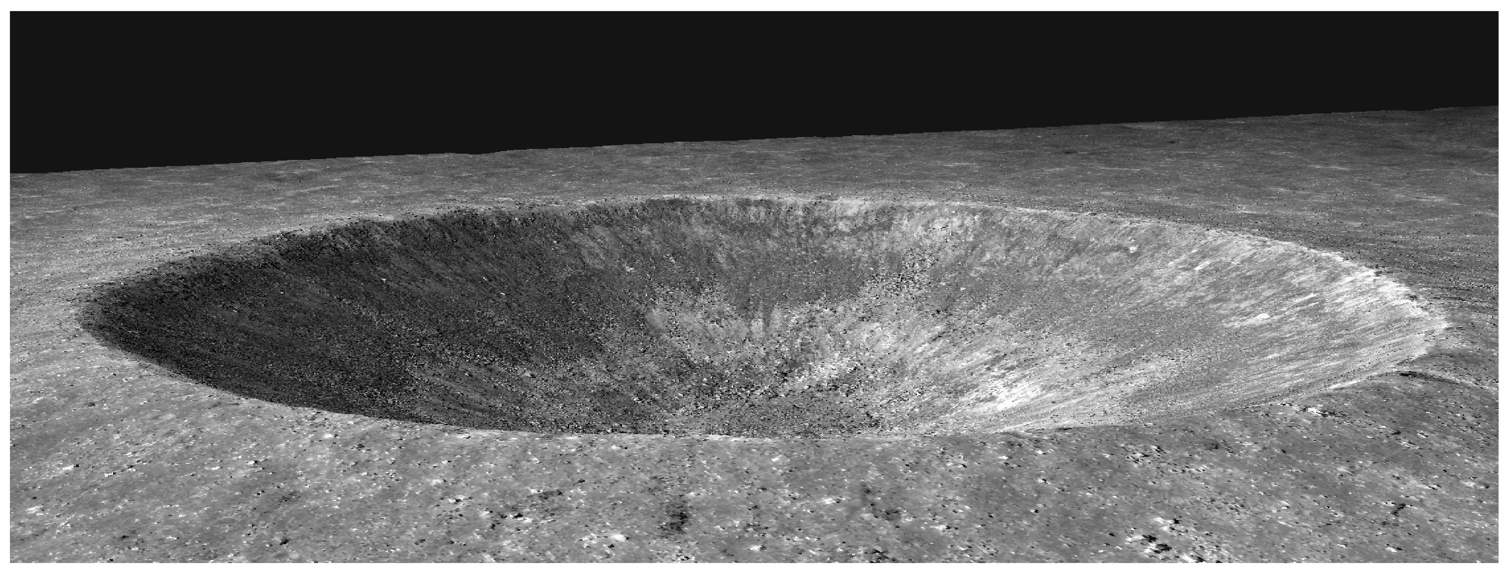

FIG 3 - 3D visualization of Linné crater. Orthoimage + DTM (resolution 2m).

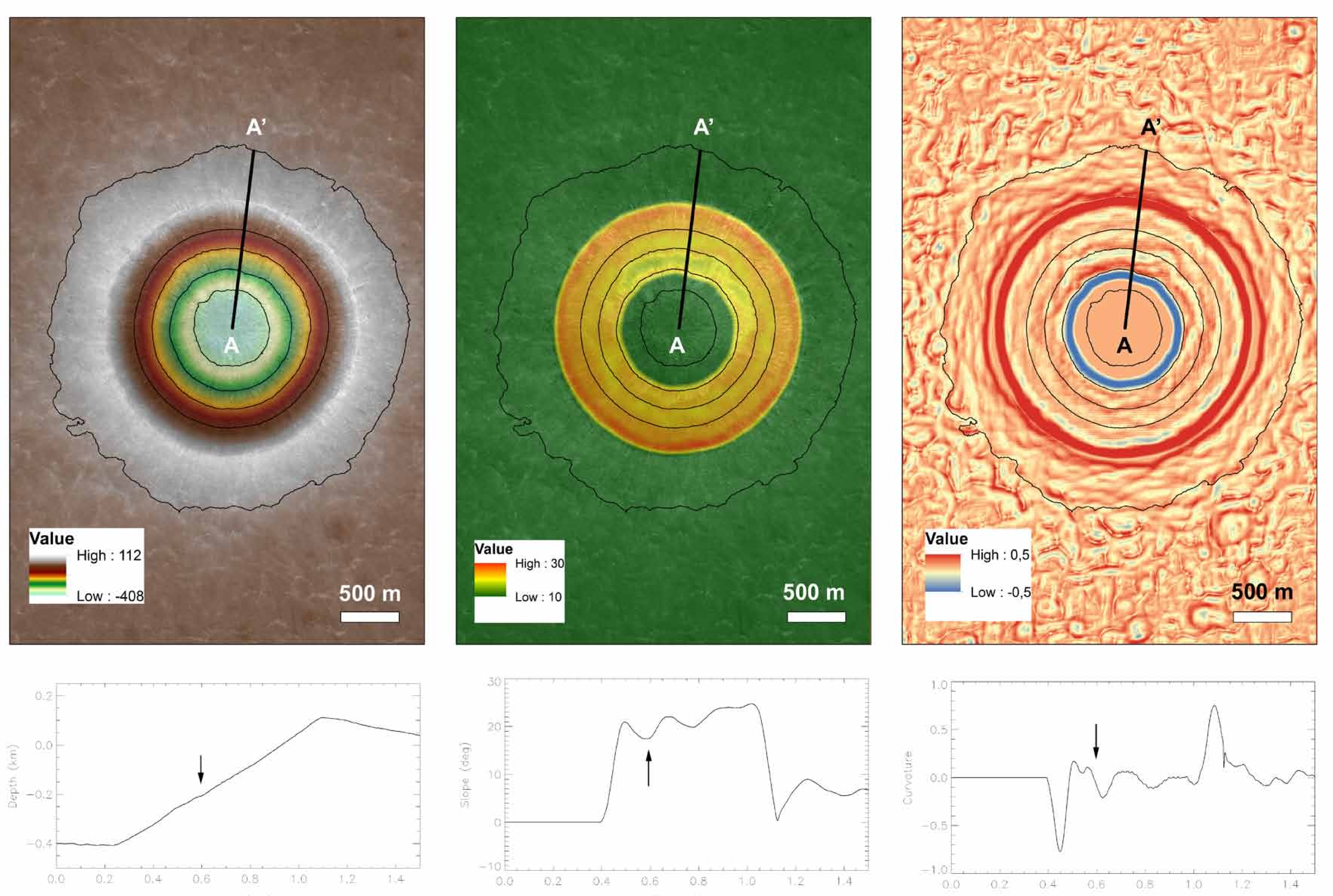

FIG.4 **A** - Topographic map of Linnè crater, with the relative topographic profile A-A'.
B - Slope classification enhance automatically rim crest, inner and outer slopes and floor. Under there is the slope profile A-A'
C -Profile Curvature smooted and classified, to enhance Rim Crest (red color) and morphological steps of the inner slope. Under there is the curvature profile A-A'
The arrows on the profiles indicate the presence of a morphological step.

MORPHOMETRIC ANALYSIS

In order to understand the invaluable potential of morphometric techniques in planetary sciences, we have conducted such analysis on Linné crater, which represents a good example of pristine structure, and therefore it has been used so far as archetype for fresh lunar mare craters.

Our investigations gave confirmation to the numerical modelling analysis [4], supporting the presence of a rheological differentiation at 200 m depth. This boundary is ascribed to the transition from fractured material to competent one. Such transition is defined by a morphological step on the inner crater scarp, which has been emphasised by the slope and curvature maps derived from the NAC DTM (Fig. 4A-B). The classification (Fig. 6) and the intersection of slope and profile curvature (Fig. 5A-B) enhance this stratigraphic structure, otherwise unidentifiable on DTM.

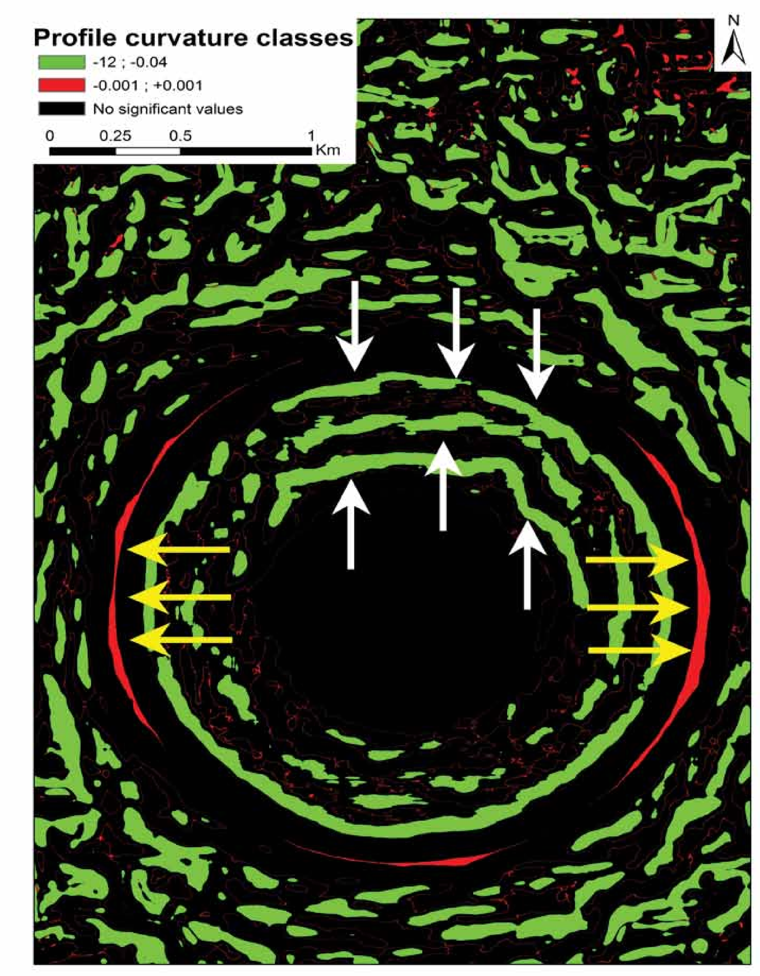

FIG 6- Specific classification of profile curvature , derived from DTM. The green boundaries are the evidence of morpholoical steps, and the red boundery is the rim crest of Linné.

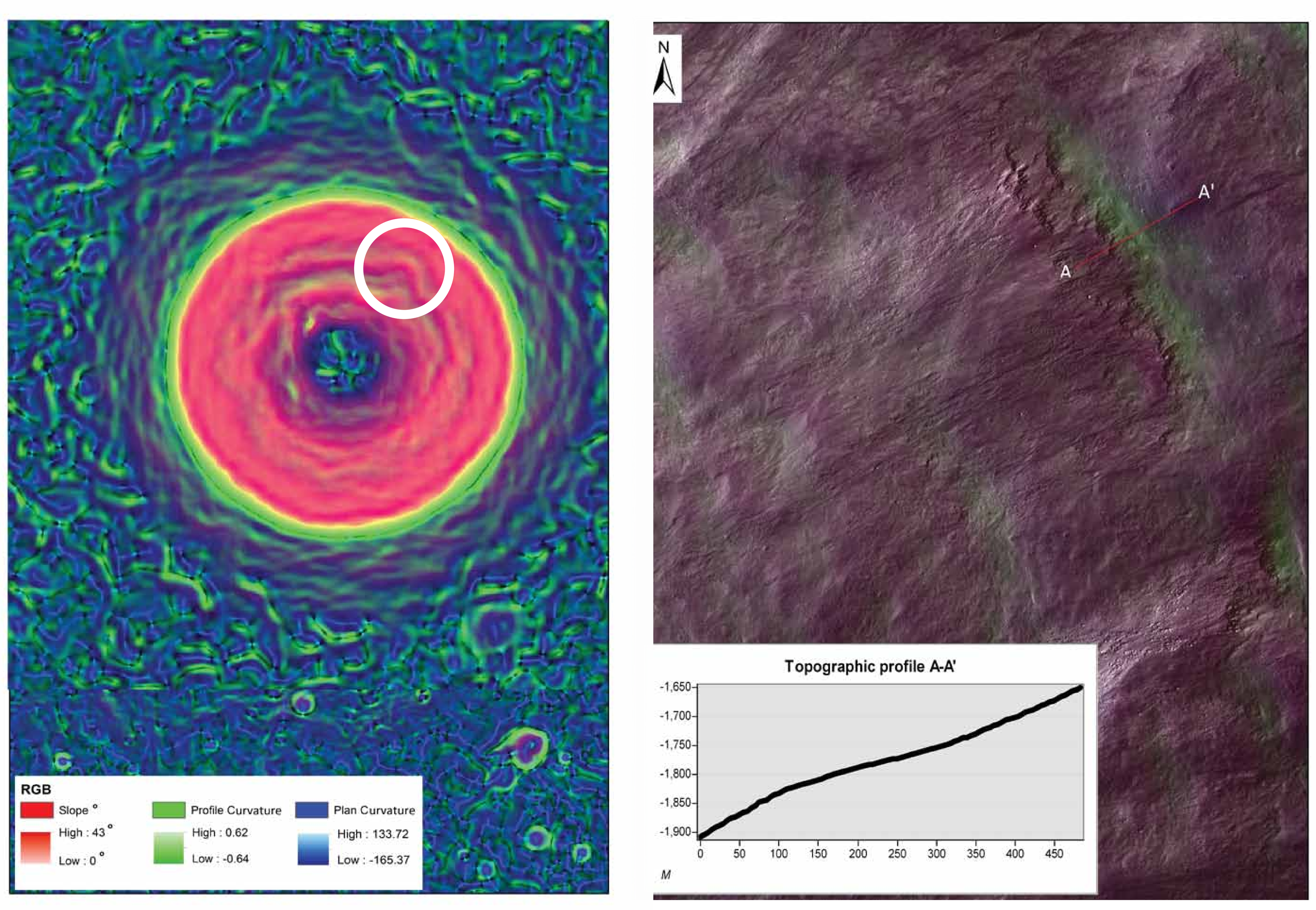

FIG.5 - A - False color composition of Slope, Profile Curvature and Plane Curvature. This elaboration show morphological steps on the inner slope of Linnè crater, enhanced by with green color.
B - Particular of the inner slope of Linnè, with a morphological step and it's relative topographic profile where can be seen some landslides (orthoimage+curvature map+slope map).

CONCLUSION

This study is only one example of morphometric analyses, which enlightens the potential of this kind of investigation. We were able to detect and quantify with extreme accuracy structures and features on planetary surfaces. This is made happen through enhancement of crater appearance. Our methodology can have important benefit on interdisciplinary works (e.g., impact modelling).

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