Regional Cataloguing of Lunar Crater Morphology.

Matthieu J. Talpe[1], Maria T. Zuber[1], Madeline E. Clark[1], and Erwan Mazarico[2]. [1]Department of Earth, Atmospheric, and Planetary Science, MIT, Cambridge, MA 02139-4307 (mtalpe@mit.edu); [2]NASA Goddard Space Flight Center, Greenbelt, MD 20771.

Altimetry profiles of lunar craters, obtained from the Lunar Orbiter Laser Altimeter (LOLA), are decomposed to extract key crater parameters. Craters are selected from four different areas of the Moon to examine regional difference. The cataloguing of key crater parameters allows for a study of crater degradation relationships to investigate geomorphologic evolution of craters, as well as an examination of the transition between simple and complex craters.

Introduction

The Lunar Reconnaissance Orbiter (LRO) has been orbiting the Moon since June 2009 [1]. LRO's 50 km polar orbits permits a global mapping of the Moon and additional data has reduced the spacing of LRO tracks down to approximately 1.8 km at the equator [2]. The tracking of LRO and its laser-ranging instrument, the Lunar Orbiter Laser Altimeter (LOLA), have produced lunar digital elevation maps of unmatched resolution (10 cm vertical resolution). This high-resolution topography data allows for a novel quantitative analysis of craters parameters, unrestricted neither by location nor lack of solar illumination.

The Mare Serenitatis (the lunar maria selected), the South-Pole-Aitken basin, and patches of the near-side highlands and far-side highlands are four regions of dissimilar geologic history whose craters are examined (see Figure 1). The four different regions bear the marks of drastically dissimilar geological processes made visible by key crater parameters analysis. The Mare Serenitatis represents the younger lunar plains made smooth by flooding; crater density is much lower than at the highlands where crater saturation is reached [3]. The South-Pole-Aitken basin is the result of a large impact, which has considerably affected the surface properties.

Analysis

Altimetry profiles of craters are decomposed in ten or more altimetry profiles, one example of which is shown in Figure 4. For each profile, the key crater parameters are computed based on the nature of the crater, averaged out for a single crater, and catalogued (see Table 1).

Simple craters are fitted via parabolic fits. The coefficient of the quadratic term quantifies the relationship between the height and the width of the parabola. regional difference are visible in Figure 2. Simple craters in the Mare Serenitatis and the South-Pole-Aitken show higher quadratic coefficients for smaller diameters, suggesting lesser crater degradation than in the highlands.

Table 1: Key Crater Parameters Computed. The nature of those parameters varies depending on the nature of the craters. Complex craters possess a set of central peaks that originate from lithospheric uplifting following the impact. Simple craters result from smaller impacts that excavate lunar material in parabolic-like shape.

Crater Type	Parameter	Units
All	Height	Kilometers
	Diameter	Kilometers
	Longitude	$^\circ E$
	Latitude	$^\circ N$
Complex	Floor Angle	°
	Wall Angle	°
	Degradation Angle	°
Simple	Quadratic Coefficients	Dimensionless

regional difference between the distribution of simple and complex craters is made visible in Figure 3. The South-Pole-Aikten basin and the Mare Serenitatis hold a higher ratio of simple to complex craters, suggesting a lower number of large impacts in more recent times.

Complex craters are fitted with slopes that represent wall slopes, degradation slopes, and a floor slope. The degradation slopes originate from wall degradation and accumulation of debris at the base of the crater walls [4]. Degradation angles show higher correlations with wall angles in Mare Serenitatis, while in the highlands degradation angles represent a larger portion of the wall angles.

Summary

LOLA's high-resolution topography data permits a quantitative look into lunar crater morphology. Discrepancies in degradation and key crater parameter are revealed as higher resolution maps of the region examined are analyzed. This study demonstrates the promise in further analysis of key crater parameters on a global level, revealing the finer details of the lunar lithospheric structure as well as the geomorphology evolution of craters on the Moon.

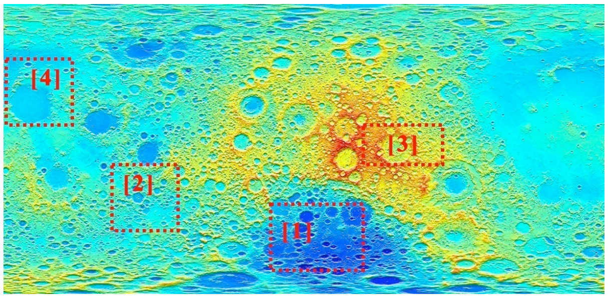

Figure 1: The four different lunar areas examined preserved the record of variations in degradation state and possibly target properties made visible by key crater parameters analysis.

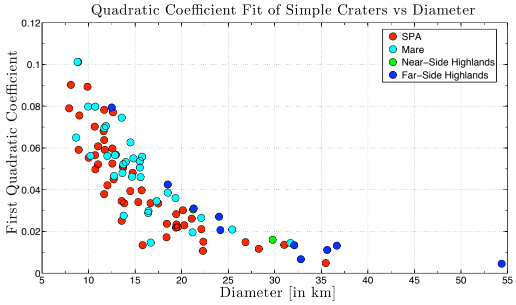

Figure 2: The ratio of first quadratic coefficient to diameter.

References

[1] Zuber M.T. et al. The lunar reconnaissance orbiter laser ranging investigation. *Space Science Reviews*, 2010.

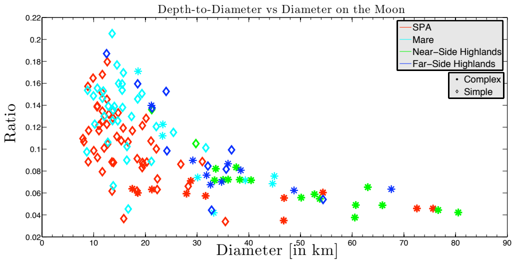

Figure 3: The depth-to-diameter graph allows for a categorization of key crater parameters and quantifies regional difference.

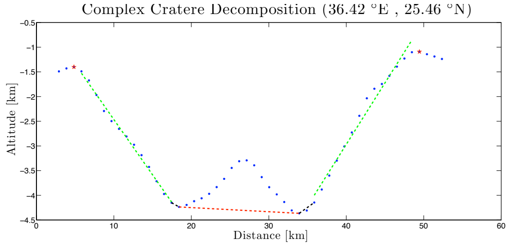

Figure 4: This Mare Serenitatis crater shows a clear central peak. The LOLA altimetry profile is decomposed to extract two wall angles (green slopes), two wall degradation angles representing the slumping of the crater wall (black slopes), one floor angle (red slope), the diameter, and depth.

[2] Smith D.E. et. al. Initial observations from the lunar orbiter laser altimeter. *Geophysical Research Letters*, 2010.

[3] James W. Head et. al. Global distribution of large lunar craters: Implications for resurfacing and impactor population. *Science*, 2010.

[4] Kirkby M. J. and Statham I. Surface stone movement and scree formation. *The Journal of Geology*, 1975.