INVESTIGATION OF THE RELATIONSHIP BETWEEN SUBSURFACE STRUCTURE AND CRATER MORPHOLOGY OF LUNAR IMPACT CRATERS FROM LUNAR ORBITER LASER ALTIMETER (LOLA) OBSERVATIONS. Michael M. Sori[1] and Maria T. Zuber[1], [1]Dept. of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambrdige, MA, 02139 (mms18@mit.edu).

Introduction: New data [1] obtained from the Lunar Orbiter Laser Altimeter (LOLA) [2] aboard the Lunar Reconnaisance Orbiter [3] spacecraft are providing the most spatially dense and accurate measurements of lunar topography to date. LOLA profiles are particularly well suited for the quantitative characterization of impact structures, in order to elucidate the nature of the process of hypervelocity impact crater and basin formation and modification. This study seeks to understand whether and if so how crater morphology is affected by subsurface structure. LOLA data are used to compute the depth-to-diameter ratios of large impact craters and basins (>60 km in diameter) found in the lunar highlands to those found within the South Pole Aitken (SP-A) basin.

Depth-Diameter Relationships of Lunar Craters and Basins: Impact craters and basins are the most pervasive distributed features of lunar topography. These structures follow a size-morphology sequence. From smallest to largest, this sequence is: simple craters, complex craters, multiringed basins. In previous study, it was observed that transitions between these crater types are gradual [4]. The transition zone between complex craters and multiringed basins on the Moon occurs approximately for diameters in the range of 130 km to 280 km [5].

The depth-diameter relationship of impact features changes between each type of crater [6]. But to date there has not been a study of whether there is any relationship between depth-diameter ratio and terrain type. In particular, ratios of larger craters and basins have not yet been systematically measured with a high-quality data set of globally consistent quality. A quantitative understanding of these ratios will allow investigation into both impact processes [4] and sub-surface lunar structure [7].

LOLA Observations: Now, LOLA [2] on LRO [3] has provided the most accurate and extensive topographic data ever taken for the Moon [1]. LOLA provides both more highly-resolved data, over 3×10^9 measurements of elevation, and far better spatial coverage of the lunar surface than all previous laser altimeters. This data can be used to accurately calculate depth-diameter ratios of large craters and basins in different regions of the Moon and compare them to results previously obtained.

LOLA [2] ranges to the surface with 5 beams, 10-12 m apart, distributed in an X-pattern, at a rate of 28 Hz. In the LRO mapping orbit, the instrument places 5-m spots on the lunar surface spaced ~50 m along track. The range precision of the instrument is 10 cm and the radial accuracy using preliminary navigation orbits is <1 m.

Procedure: In order to examine the depth-diameter ratios of large lunar impact structures, LOLA data has been used to study dozens of large craters and basins in both the SP-A basin and the lunar highlands. Figure 1 shows the 23 impact features considered in the SP-A basin.

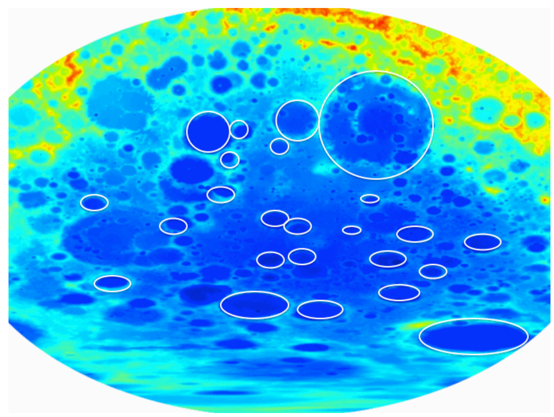

Figure 1: Topographic map [1] of the SP-A basin, with each impact structure considered in this study marked by a whie oval.

For each impact feature, altitude profiles were extracted from a topographic map provided by the LOLA science team [10] using a software program [11]. Accurate depths are estimated for each crater, so that depth may be plotted as a function of diameter for the impact features.

Many data points are taken from each crater profile and are averaged to get a result for the crater bottom's altitude. Only points corresponding to the crater bottom are considered; points corresponding to crater walls or peak rings are omitted. Furthermore, profile points that correspond to smaller "subcraters" from other direct impacts or ejecta are excluded. Eight such profiles are taken for each crater along different directions, and a final measurement for the altitude of the crater bottom is reached. This altitude is subtracted from the altitude of the crater rim to estimate crater depth.

Two profiles for one of the SP-A impact features studied, Antoniadi, are give n in Figures 2 and 3. Antoniadi has approximate coordinates 187° E, 69° S, and a diameter of 141 km. Its size places it at the lower bound of the transition phase from complex crater to multiringed basin.

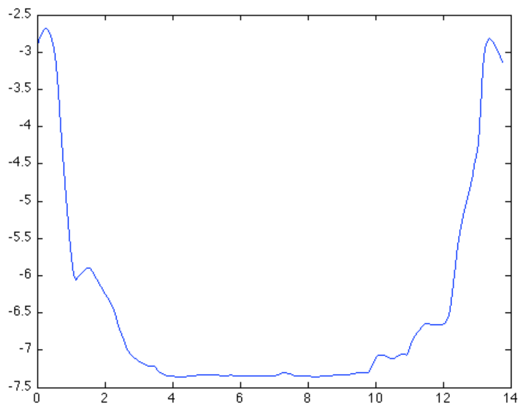

Figure 2: Profile of Antoniadi, in the latitudinal direction. Units are in degrees (x-axis) and kilometers (y-axis)

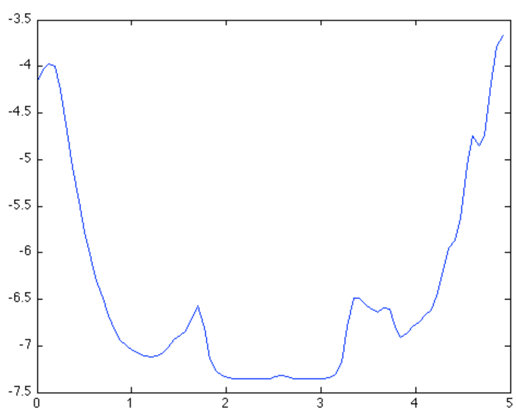

Figure 3: Profile of Antoniadi, in the longitudinal direction. Units are in degrees (x-axis) and kilometers (y-axis)

For the latitudinal profile of Antoniadi (Figure 2), points between x=4 and x=8.5 are considered, and for the longitudinal profile (Figure 3), points between x=2 and x=3 are considered. These two profiles give altitudes for crater bottoms as -7.3427 km and -7.3488 km, respectively. Six more profiles are taken in different directions through the crater and also used to calculate the altitude of the crater bottom. The results yield a depth of 4.288 ± .192 km and a depth-to-diameter ratio of .0305 ± .0017.

Similar profiles are taken for each crater or basin considered in both the SP-A basin and lunar highlands. A plot of the depth-diameter relationsip of large craters in basin in the SP-A basin, including Antoniadi, is shown in Figure 4.

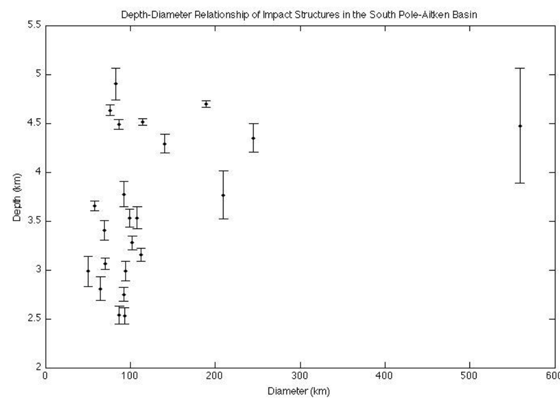

Figure 4: Depth as a function of diameter, both in km, for the 23 impact features shown in Figure 1. Antoniadi can be seen approximately at (141, 4.3).

Discussion: The analysis continues to accumulate measurements of craters and basins in the lunar highlands and SP-A basin for a comparison of the two regions. Results will be used to better understand the effect the target surface has on impact processes.

References: [1] Smith D.E. et al. (2010) *Geophs. Res. Lett.* **37***,* doi:10.1029/2010GL043751. [2] Smith D. E. et al. (2010) *Space Sci. Rev.* **150**, 209. [3] Chin G. et al. (2007) Space Sci. Rev. 129, 391.[4] Melosh, H.J. (1989), *Impact Cratering, A Geologic Process*, Oxford University Press, New York. [5] Williams, D.E. (1987) *U.S. Geol. Surv. Prof. Pap. 1348.* [6] Pike, R.J. (1974), *Geophys. Res. Lett.,* **1** 291. [7] Williams, K.K. and M.T. Zuber (1996), *Lunar and Planetary Science*, **27** 1441. [8] Baldwin, R.B. (1963), *The Measure of the Moon,* Univ. Chicago Press, Chicago. [9] Pike, R.J. (1976), *The Moon,* **15** 463. [10] Smith D. E. et al. (2009) this issue. [11] Luis J. F. (2007). *Computers & Geosciences,* **33** 31-41.