IMPACT MELT VOLUME ESTIMATES OF SMALL- TO MEDIUM-SIZED LUNAR CRATERS FROM LUNAR RECONNAISSANCE ORBITER DATA.

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Introduction: Direct measurements of the volume of melt generated during cratering have only been possible using data acquired at terrestrial craters. These measurements are usually the result of areal mapping efforts, drill core investigations, and assessments of the amount of erosion a crater and its melt sheet might have undergone. Good data for melt volume are needed to further test and validate both analytical and numerical models of melt generation on terrestrial planets, whose results can vary by as much as a factor of 10 for identical impact conditions. Such models are used to provide estimates of the depth of origin of surface features (e.g., central peaks and rings) seen within craters and could influence the interpretations of their diameter-to-depth relationships. For example, high velocity impacts (>30km/s) on Mercury are expected to produce significant melt volumes, which could influence crater aspect ratio.

The Lunar Reconnaissance Orbiter is returning a wealth of new data: high resolution (≤1m/pixel) LROC observations [1] and LOLA altimetry [2] (spatial sampling ~56m, 10cm vertical precision). Such data are of such quality and coverage that melt volume estimates can be obtained for many of the small-to-medium-sized (1km<D<20km) fresh craters.

Preliminary results indicate that melt volumes can vary significantly for given crater sizes, sometimes significantly exceeding estimates from current numerical and analytical models in the literature for impacts on the Moon. Other times the measured melt volumes are significantly less than models.

Data: For this work, we use LROC and LOLA data acquired between commissioning (July 2009) and the end of the Exploration mission (September 2010). Those observations were released publicly in December 2010 through the Planetary Data System [3] (LRO release #4). We selected relevant observations from 188,270 Moon-targeted NAC frames, and from 5,190 LOLA orbits.

Methodology: In previous work [4], a few craters were selected and inspected with LROC NAC images for the presence of impact melt (**Figure 1**). LOLA data were then used to best fit the crater shape outside of that melt region, and infer its volume (between the measured floor and the best-fit shape floor). The obtained values are likely upper limits on the actual melt volumes, as other processes in the crater evolution (e.g., slumps) can contribute to the central flat floor. In this work, we increase the number of surveyed craters, by using an extensive crater catalog which include small- to medium-sized craters. Because visual inspection of every crater with LROC data is not practical, we use the LOLA data first to automatically fit the crater shape and detect if its center is flat-floored. If that is the case, tentative impact melt sheets identified from LOLA data are then inspected visually with LROC imagery, and their spatial extent measured. Their volume is calculated similarly, as the volume between our idealized best-fit shape and the actual crater floor.

Lunar Crater Catalogue: We expand on previous work [4] by using a recent lunar crater catalogue (LU58357GT) [5] to automate certain aspects of the preparatory work, namely selecting craters and estimating their center/diameter. This crater catalogue contains 58,357 craters, and is mostly complete down to

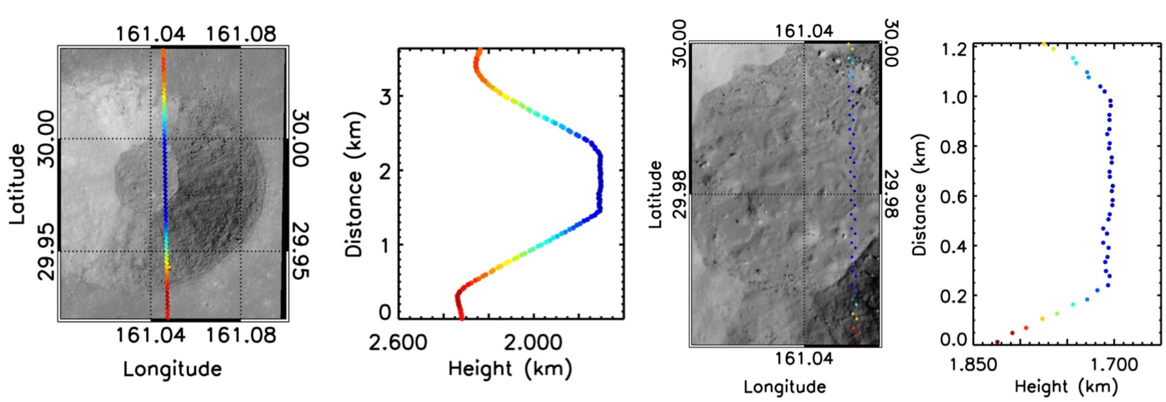

Fig.1 Example of LROC NAC and LOLA observations of an impact melt sheet in an unnamed crater.

~8km diameter craters (**Figure 2**). That crater database also includes their depths (**Figure 2**), which are consistent with previous findings, with a transition diameter around 15-20km [6-7], and show the good quality of the catalogue.

Selection of Craters: We focus on the 46,231 craters with diameters between 1 and 20 kilometers, a range limited to mostly-simple craters with expected axisymmetric shapes and to craters which are statistically likely to be sampled by at least one LOLA track.

The coverage of the craters with the LROC NAC observations is in general good, with about 46% of the craters in our diameter range (21,267 out of 46,231) being sampled at least partially by released NAC images. **Figure 3** shows that the distribution of craters with very high coverage is not too steep, and should allow for good characterization of a number of craters.

By its construction, with an automatic detection algorithm using a high-resolution LOLA DEM (up to 1/512° for the depth calculations), the catalogue only contains craters sampled by LOLA. However, the altimeter data tracks do not necessarily go through the crater central part, which is where impact melt sheets are more likely to be detected [4]. This further reduces the number of usable craters.

References: [1] Robinson et al. (2010), Space Sci. Rev., Vol.150, 1-4, 81-124; [2] Smith et al. (2010), *Geophys. Res. Lett.*, 37, L18204; [3] NASA Planetary Data System, http://geo.pds.nasa.gov/missions/lro/; [4] Barnouin et al. (2010), AGU Fall Meeting, Abstract #P53C-1540; [5] Salamunićcar G. et al. (2011), LPSC XLII, Abstract #1449; [6] Pike, R.J. (1974), Geophys. Res. Lett., 1 291; [7] Sori and Zuber (2010), LPSC XLI, Abstract #2202.

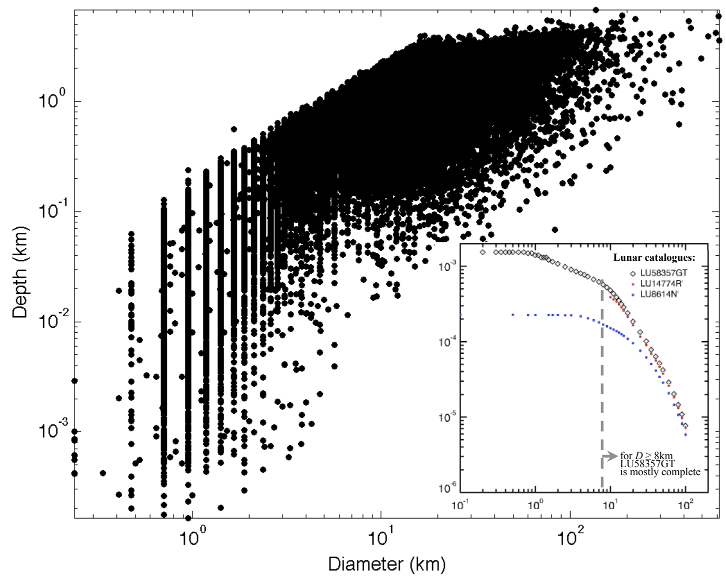

Fig.2 Depth vs diameter plot of all the craters in the LU58357GT catalogue [5]. The R-plot (inset) shows that the catalog is nearly complete for D ≥ 8km.

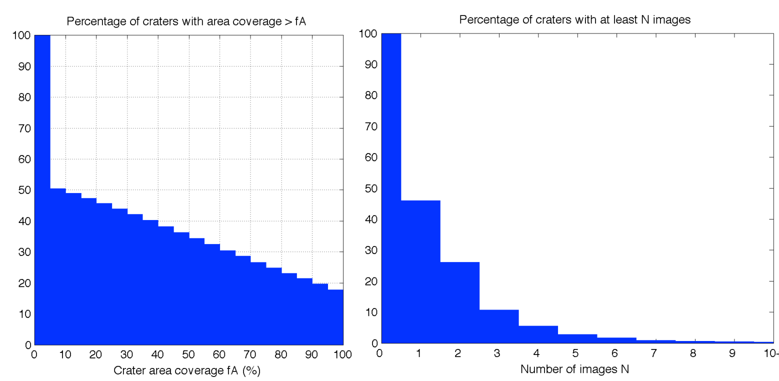

Fig.3 Cumulative histograms showing the crater area covered by available NAC images (left), and the number of NAC images overlapping at least in part each crater (right).