Lunar Simple Crater Impact Melt Volumes

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Abstract

Impact melt is observed in simple lunar craters having diameters as small as <200 m. The presence of ponds of impact melt on the floor of such small craters is interpreted to indicate vertical impacts. Data from the LRO LROC and LOLA experiments allow quantitative estimates of the volume of impact melt in simple crater. Such estimates allow for validation of theoretical models of impact melt generation and examination of target effects. Preliminary data have considerable scatter but are broadly consistent with the models.

1. Introduction

The formation of impact melt during cratering is expected due to the large amounts of kinetic energy imparted into the target [1-6] and is observed in a spectrum of lunar and planetary craters [7-11]. At small diameters, the expected volume is minimal and most would be ejected from the crater. Recently, however, Plescia and Cintala [12] identified a numerous simple highlands craters having well-defined melt pools on their floor (Fig. 1) and attributed these deposits to vertical impacts. Previous studies of lunar impact melt have only reported on the presence of impact melts and their morphologies. Here we present quantitative estimates of the volume of melt, examine those volumes in light of the target, and compare them with theoretical estimates.

2. Questions

Estimates of the volume of impact melt associate with an impact allow for understanding a variety of important questions: 1) what is the volume of melt as a function of crater diameter for simple impact craters; 2) how do the estimated volumes compare with the model predictions; 3) do differences occur between mare and highlands targets; 4) do differences occur as a function of diameter that might be indicative of the influence of target layering; 5) how do volume change as a function of impact angle?

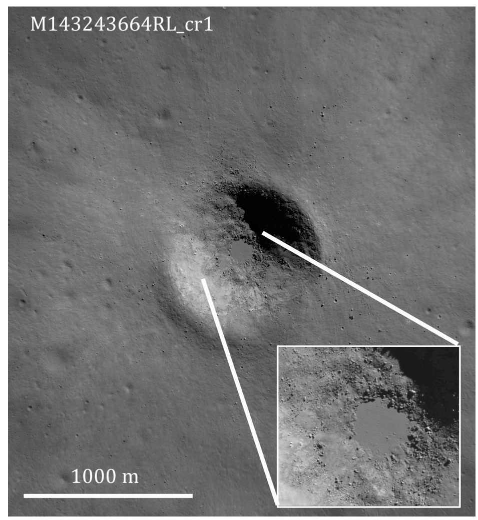

Figure 1. A 1 km diameter crater with 150 m pool of impact melt on the floor. Inset in lower right is an expanded view of the floor. LROC M143243664RL. 57.3111°N / 210.397°E

3. Techniques

The approach follows that of [13]; a topographic profile (e.g., LOLA, WAC DEM) crossing the crater provides the present topography. The profile's upper portion (above the floor) represents the original crater wall; the lower portion the present floor (Fig. 2). A variable order polynomial or a Gaussian function is fit to the upper crater wall profile (not including the floor) representing the original crater profile. The difference between the observed profile and that from the fit represents the melt volume. For volume calculations, craters will be assumed to be axi-symmetric.

4. Discussion

There is some terrestrial data for melt volumes (e.g., [14-16]) but those data are limited and significant uncertainties exist in both the volume and associated transient crater diameter. Thus, they provide only limited tests for the models. Fresh lunar craters provide a much more robust means to assess the melt volume over a range of diameters and in different geologic environments. Simple craters (i.e., <15-20 km; [17]) are appropriate targets because of their simple interior structure, particularly compared with the complex structure of larger craters. The typical bowl-shape can be approximated by the wall topography, the amount of post- and syn-rebound is small, and a good approximation of the cavity volume can be established. Estimates of the melt volume probably represent a maximum as any slumping of wall material occurring before emplacement of the melt is not considered.

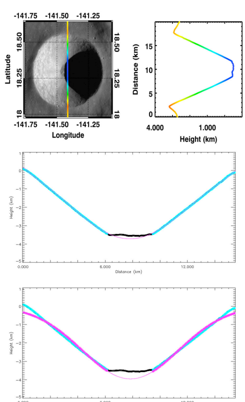

Figure 2. *Model fitting to topographic profile. Upper panel: crater with LOLA topography. Center panel: topography with polynomial fit; Lower panel: topography with Gaussian fit. The difference between the observed and modeled topography is interpreted as melt.*

5. Conclusions

Preliminary estimates of the volume of impact melt in simple lunar craters are broadly consistent with the theoretical models of melt production, but have considerable scatter. The scatter may be the result of the relatively few data points collected so far. Additional data being assembled will provide better constraints on the volumes and will allow an understanding of the influence of target properties (e.g., mare vs. highlands). Estimates of the volume can provide validation of models.

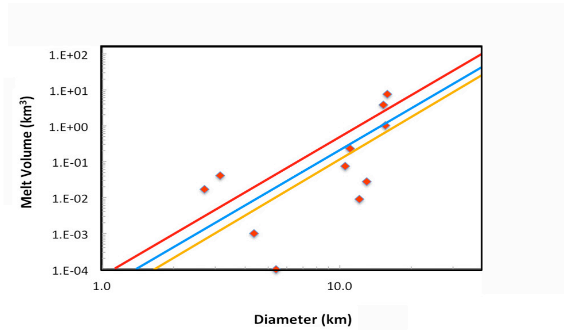

Figure 3. *Melt volumes estimated for several craters compared with models of melt volume. Red: Cintala and Grieve [1]; Blue: Pierazzo et al. [2]; Orange: Watters et al. [3] modified to account for the latent heat of melting [18].*

References

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