TOWARDS AN UNDERSTANDING OF INITIAL CRATER ROCK POPULATIONS: BOULDER DISTRIBUTION AROUND COPERNICUS CRATER.

S. Mazrouei[1] and R. R. Ghent[1, 2], [1]Department of Earth Sciences, University of Toronto, Toronto, ON, Canada. [2]Planetary Science Institute, Tucson, AZ, USA.

Introduction: The lunar regolith contains a record of 4.6 billion years of Solar System history, and is continuously formed and overturned by impacts of objects over many orders of size magnitude. Understanding the nature and evolution of the lunar regolith is a key element of the quest to understand the evolution of the Moon as a whole, as well as the Earth-Moon system.

Despite the fact that to first order, we understand how regolith materials are generated, many fundamental gaps remain. For instance, how fast does comminution of large rocks or bedrock to form the fine components of the regolith occur? How does that rate relate to the flux of impactors, and how have both changed over time? Recently, Ghent et al. [1] have shown that the rockiness of large craters' ejecta, derived from the Lunar Reconnaissance Orbiter's Diviner thermal radiometer data [2], provides a new method for estimating the ages of Copernican craters younger than roughly one billion years old. Young surfaces have fresh, sharp rocks, while older terrains have lower rock abundances. The rate by which rocks are eliminated is then quantified using the rock abundances found on or near lunar craters with known absolute ages.

The method in [1] is based on the notion that large rocks transform to regolith over time, and documents the inverse relationship between the rockiness of craters' ejecta and their age – as crater age increases, the rockiness of a crater's ejecta decreases. In previous work [3, 4], we used this method to date all craters larger than 10 km and younger than roughly one billion years old. This method assumes that all impact craters 10 km and larger produce statistically similar initial rock populations, independent of their location on the Moon.

In pursuit of detecting whether the survival time of boulders varies for rocks of different sizes on the Moon, as well as distinguishing how much of this rock break down is due to micrometeorite impacts versus other factors (such as thermal fatigue), we need to gain a better understanding of how initial rock production in an impact varies based on the following factors. a) Crater size: it has been shown that resulting boulder sizes from an impact are proportional to the crater diameter [5]. Consequently, the maximum boulder diameter from an impact crater increases with crater diameter [6], though the survival time for rocks of different sizes from the initial impact population remain ambiguous. b) Target terrain (mare versus highlands): different target strengths in an impact result in different boulder sizes [5]. However, the survival time of different rock types on the Moon (for example basalt from the mare and anorthosite from the highlands) are unknown.

To understand whether the survival rate of different boulders varies amongst Copernican craters, we seek to determine how the ejecta rock populations of craters with different sizes and target terrains differ. In addition, we want to examine differences between rock populations of craters of similar sizes but different ages. We do this by mapping rock locations and sizes in the ejecta blankets of several craters.

Methodology: Here, we report on preliminary results of boulder counts for Copernicus Crater, since it is one of the best studied and dated craters, with a model age of ~800 Ma [e.g., 7]. Due to the large size of this crater (93 km in diameter), we only map boulders in three 20° wedges in different radial directions (north, southeast, and southwest) to a distance of 1 radius from the crater rim (Figure 1). We use the Integrated Software for Imagers and Spectrometers (ISIS) to create image mosaics for each section using selected images from the Lunar Reconnaissance Orbiter's Narrow Angle Camera (LROC NAC). The selected frames are high resolution NAC images with resolutions ranging from 0.5 to 1.25 m/pixel, most at ~1 m/pixel.

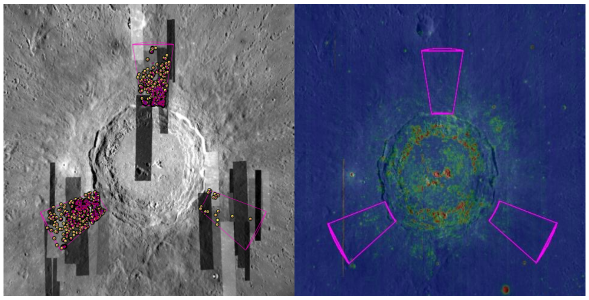

Figure 1: Copernicus Crater a) LROC WAC image with the NAC mosaics overlain. Yellow dots represent the mapped boulders. b) Diviner Rock Abundance map of Copernicus.

We use the ArcGIS Crater Helper Tools to map boulders. Each rock is approximated as an ellipsoid and its long and short axes are recorded with the assumption that the third axis has the same length as the short axis. We then take the boulder's diameter as that of a sphere whose volume is equal to that of the ellipsoid [8].

Preliminary Results and Discussion: We have mapped about 2000 resolvable boulders larger than 10 m, which is arguably larger than the smallest detectable boulder based on the image resolutions (generally assumed to be 2-3 pixels). This discrepancy is due to the fact that a large selection of NAC images does not exist in our large mapping areas, and our image mosaics consist of NAC frames with different incident, emission, and phase angles. These resolution effects therefore render it difficult to map smaller sized boulders without introducing uncertainties in the number of smaller boulders. It should be noted that smaller sized boulders were detected in some NAC frames, but we only mapped all boulders larger than 10 m to be consistent across all frames. We observe a rollover in boulder sizes < 20 m in the preliminary size-frequency distribution (SFD) plot (Figure 2), which we interpret as an indicator of an incomplete dataset. The boulder distribution in the northern and southwestern wedges are very similar, while the southeastern distribution differs greatly. This trend is also observed in Figure 1b, where the southeastern part shows a lower rock abundance. Therefore, mapping boulders in a few different directions, and normalizing their distribution by area is the most representative of the overall boulder distribution in the ejecta blanket.

The preliminary SFD for boulders > 20 m has a slope of -3.3 for the overall boulder distribution, which is within the predicted range of -1.8 to -3.7 for lunar boulders as described in [9]. Our slope lies within the steeper range of the previously mentioned power indices, indicating that perhaps smaller boulders are more numerous compared to larger ones. One plausible explanation for this observation is that larger rocks in Copernicus Crater's ejecta blanket have been broken down by micrometeorite bombardment over time.

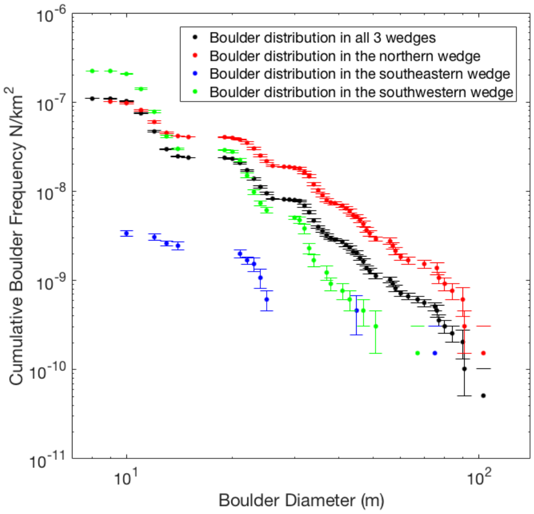

Figure 2: Boulder size-frequency distribution in the ejecta of Copernicus crater.

Current Work: Continuing this work, we will analyze boulder distribution around other Copernican craters, which will allow us to compare boulder distributions between different terrains, crater ages and sizes. Next, we will map boulders on the ejecta blanket of two smaller craters (~10km diameter), one located on the mare and the other on the highlands, both similar in age to Copernicus. This will allow us to directly compare the SFD of boulders in the ejecta blanket of two similarly sized craters on different terrains to determine whether the rock populations evolve the same regardless of the impact location on the Moon. Additionally, comparing the size-frequency distribution of boulders in the ejecta of Copernicus versus a smaller crater of similar age (different initial rock populations) will help us constrain the survival time of different rock sizes.

Furthermore, mapping boulders in the ejecta of a crater similar in size to Copernicus (which should have similar initial rock populations) but much younger (such as Tycho crater) will allow us to see how a certain boulder population evolves over time. The results of this study will also help us gain a better understanding of rock abundance values derived from LRO's Diviner and the rate of rock to regolith transformation, as the Diviner rock abundance values only represent the percentage of each pixel covered with exposed rocks independent of their size.

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