A MODEL FOR THE EVOLUTION OF LUNAR ROCK SIZE-FREQUENCY DISTRIBUTIONS. O. Rüsch, R. M. Marshal, W. Iqbal, J. H. Pasckert, C. H. van der Bogert, M. Patzek, Institut für Planetologie, Westfälische Wilhelms Universität Münster, Münster, Germany.

Introduction: At the centimeter and meter scale the surface of the Moon is populated by rocks that originated as impact ejecta. The characteristics and evolution of this material are of interest for their contribution to regolith formation. In fact, rocks decrease in number with time [e.g., 1, 2] through impact bombardment [e.g., 3] and the produced fragments become particles of regolith. Boulders and larger blocks contribute to the thermal emission of the lunar surface [e.g., 4] and they are potentially hazardous for robotic missions [e.g., 5]. Here we report on our effort [6] to update the Monte Carlo model of rock catastrophic rupture presented by [3]. We show that this model is sufficiently accurate to reproduce the measured block size-frequency distribution (SFD) around large lunar impact craters and that, therefore, it can be used as a technique to date lunar block fields.

Model: In its simplest form, the model of [3] is a comparison between the energy necessary to catastrophically shatter ("erase") a block and the energy delivered by meteoroids impacting a block, accumulating over time. These energies are dependent on the block size and several functions have been proposed in the past to describe such dependency. The functions derived to describe lunar conditions, namely the strength of lunar blocks and the meteoroid SFD impacting the Moon in the centimeter to meter range, are not sufficiently well known. Here, we updated the model of [3] to calculate the expected size-frequency distributions of blocks based on several combinations of these functions. These model distributions are compared to a measured size-frequency of blocks of known isotopic age to determine the best representative functions. This last step constitutes a calibration of the block erasure time and assumes that the initial distribution of blocks follows a power law.

Results: We find that the block SFD changes in shape with time from a power law to an exponential distribution (Figure 1). In Figure 2, we show the new destruction rate for lunar blocks of varying sizes and compare it to the original model of [3]. In Figure 3, we demonstrate that the model can reproduce the observed size distribution of blocks measured on Lunar Reconnaissance Orbiter Narrow Angle Camera (LROC NAC) images [7], in particular the inflection of the curve starting at about 10 meters with respect to the initial distribution. In Figure 4, we show how the model fit depends on the slope of the distribution (power law exponent) and the surface exposure age.

Discussion: The new destruction rates agree with previous independent estimates [1,2]. In addition, the decrease in destruction rate at sizes below ~5 cm confirms the results of [8]. The best fit age obtained for block fields on Aristarchus crater ejecta is within the range of possible ages proposed for the crater via crater SFD measurements [9]. The updated model of [3] presented here allows the estimation of both the exposure age and initial abundance of a block field from a measured block SFD. The model can also be used to predict block abundances below the current image resolution (0.5 meter).

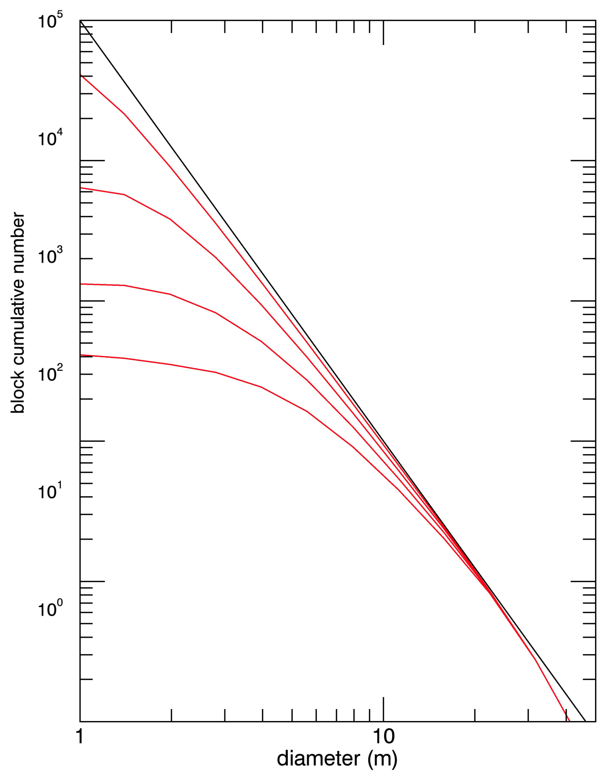

Figure 1. Model size-frequency distributions for a block field on the Moon. The initial distribution (black) follows a power law. The decreasing abundances as the population evolves with time are shown as a function of size at different arbitrary time units (red).

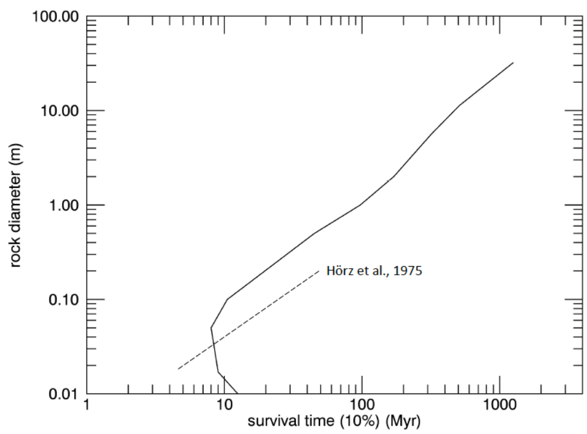

Figure 2. Survival time (Myr) or the time necessary to catastrophically shatter a rock of a given diameter with 90% probability. The dashed line is the estimate of Hörz et al., 1975 [3].

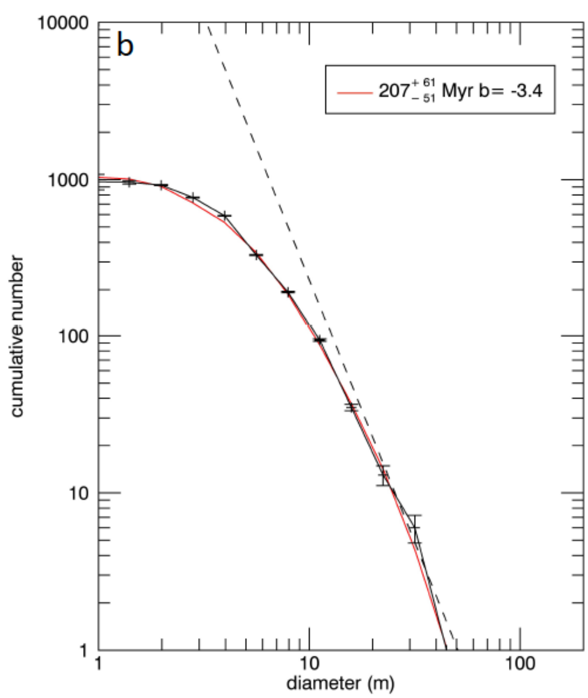

Figure 3. Measured and model cumulative size-frequency distribution of blocks at the rim of Aristarchus crater. Measurements shown with crosses, model initial distribution (t=0) shown by the dashed line, and model best fit isochron shown in red. There is no image resolution bias at low block diameters. The reported upper and lower age estimates are defined as the ages obtained with 50% higher RMS than the best fit.

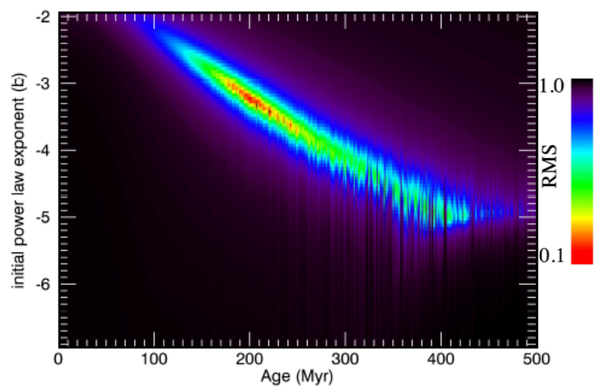

Figure 4. Color-coded RMS deviation of normalized residuals between model and measured block size-frequency distributions at the rim of Aristarchus (Figure 3) as a function of block field age and power law exponent of the initial distribution.

Conclusions: In this study, the catastrophic rupture model from [3] is successfully updated with recent formulations of energy functions and meteoroid SFDs impacting the lunar blocks. The distributions resulting from the updated model are then compared with lunar surface block counts on regions that have been previously dated. From the results of the updated model, it is evident that SFDs can be successfully utilized to derive an estimate of the exposure age of a given boulder field.

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