THE DISTRIBUTION OF BLOCKS AROUND A FRESH LUNAR MARE CRATER. Mark J. Cintala,* James B. Garvin and Stephen J. Wetzel,** Department of Geological Sciences, Brown Univ., Providence, RI 02912 (*Present address: NRC Research Associate, SN6-NASA Johnson Space Center, Houston, TX 77058; **NASA PGUR Intern, Summer, 1981).

Impact-generated blocks are an important component of planetary regoliths; indeed, they have been observed on the Moon, Phobos, Deimos, presumably on Mars, and perhaps on Venus. Because the nature and abundance of such blocks might yield important information on various physical processes, ages of surfaces, and local and regional geology, it is necessary to understand the mechanisms of block production during impact, their emplacement, and the final characteristics of the resulting population. This report addresses the size and spatial distributions of blocks in the ejecta deposit of a small lunar mare crater.

DATA: The crater selected for this study is 520 m in diameter and 140 m deep as measured from the rim crest. It possesses a block-rich ejecta blanket and, located about 16 km from the Apollo 12 landing site at 2.67°S, 23.49°W, falls within the high resolution coverage of Lunar Orbiter III(frame LO III 153H2). Insofar as the mean regolith thickness in this area as determined through the use of small crater morphology is only ∿7 m, the block population should be comprised primarily of basalts comminuted and ejected by this impact. A component of pre-existing blocks derived from the regolith is most likely present, along with shock-welded chunks of regolith; insufficient information exists at present, however, to differentiate between the three groups. The lengths of all visible blocks around the crater were digitized, a process which also provided block locations relative to the crater; in addition, the widths were recorded when possible, along with a quality factor describing the reliability of the measurement. With a theoretical resolution of 1 m, the photograph yielded 8098 blocks at distances of 200 to 1625 m from the crater's center.

RESULTS: Numbers -- The cumulative number of blocks as a function of mass and size is plotted in Figure 1, along with the cumulative number percent. Masses were calculated by assuming that the blocks are rectangular prisms with a density of 3200 kg/m^3 and have widths equalling their depths. (The most reliable width measurements yield a modal value of 0.67 times the length, which is that used in the calculation.) The cumulative number of blocks decreases smoothly until masses of about 7 x 10^6 kg (equal to a maximum length axis of ∿17 m), where a drop in number occurs. The median block length in this data set is ∿3.5 m, with a corresponding mass of ∿6 x 10^5 kg. Radial Mass Distribution -- The total masses within 50 m-wide annuli have been calculated and plotted vs. increasing distance from the crater (Fig. 2). While slight irregularities exist, the data display a comforting decrease in areal density as a function of range. Radial Dependence of Maximum Block Mass -- The mass of the largest block in each 50 m-range bin is also plotted in Figure 2. Like the areal density measurements, these data show a decreasing trend with increasing, although rather large excursions do exist.

DISCUSSION: The rapid decrease in the slope of the cumulative number plot at small masses is almost certainly due to resolution/detection constraints, which should also affect the cumulative percent curve. The largest block associated with this crater has a maximum axis of 30 m — somewhat larger than the distribution constructed by Moore would suggest, but not surprising due to the considerable variation observed between craters of similar size. A power-law fit to the areal density data yields $\bar{M} = 4959\bar{R}^{-3.66}$, where $\bar{M}$ is the average block mass per unit area (kg/m^2) and $\bar{R}$ is

THE DISTRIBUTION OF BLOCKS AROUND A FRESH LUNAR MARE CRATER

Cintala, M. J. et. al.

the range from the crater center normalized to the crater radius. The exponent falls within the range of those deemed reasonable in describing the radial decay of crater rim topography,[3] but is considerably steeper than that suggested for all ejecta by McGetchin et al.[4] (-3.26) and O'Keefe and Ahrens[5] (-2.715 to -2.930). The total mass of the blocks is 1.22 x 10^9 kg; taking the regolith into account and assuming a negligible component of crater volume due to compression, the apparent crater represents a mass of 2.26 x 10^{10} kg. Thus, the blocks account only for ~5% of the maximum possible mass ejected from the crater, indicating that a much greater mass of relatively fine-grained material comprises the bulk of the ejecta. Finally, the largest blocks are found near the crater rim, although boulders of considerable size occur in the ejecta blanket at greater distances (Fig. 2). The overall trend is probably due to a number of factors, but two are suggested as being dominant. Those blocks that traveled the shortest distances should have been subjected on the average to lower shock stresses and stress gradients than most of the other blocks, since they were emplaced late in the event. Because the size of a fragment from a coherent medium is inversely dependent on the stress gradients involved in its production,[6] the large blocks should have been only weakly shocked, thus retaining much of their original coherence. Not only were the blocks ejected to greater distances subjected to higher stresses, but they also were presented with another opportunity to disrupt upon emplacement.

REFERENCES: W. L. Quaide and V. R. Oberbeck (1968) JGR 73, 5247. H. J. Moore (1971) NASA SP-232,26. M. Settle and J. W. Head (1977) Icarus 31, 123. T. R. McGetchin et al. (1973) EPSL 23, 271. J. D. O'Keefe and T. J. Ahrens (1976) PLSC 7th, 3007. E. J. Öpik (1971) Adv. Astron. Astrophys. (Z. Kopal, ed.) 8, 108.

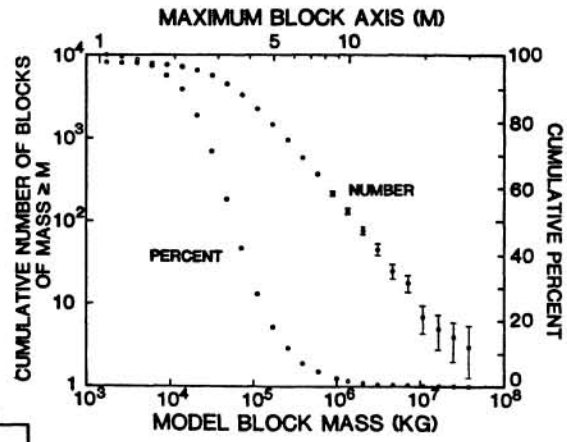

Figure 1. Cumulative number and cumulative percent of blocks as a function of mass and maximum axis.

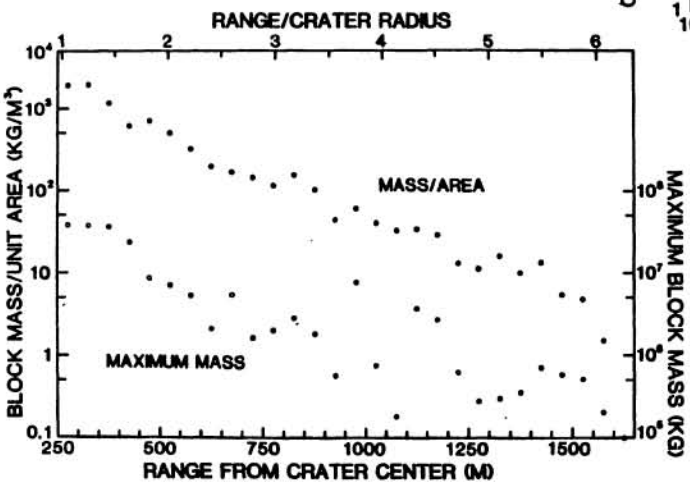

Figure 2. Areal density and maximum block mass as functions of range from the crater's center.