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NON-RANDOM CRATERING FLUX IN RECENT TIME; P.H. Schultz, Department of Geological Sciences, Brown University, Providence, RI 02912 and S. Posin, Arizona State University, Tempe, AZ 85287.

Background: Proposed periodic cycles of mass mortality have been linked to periodic changes in the impact flux on Earth (1, 2, 3). Such changes in the impact flux, however, also should be recorded on the Moon. Without returned lunar samples, crater statistics provide one of the few available tools to test this hypothesis. Small "counter-craters" are used to establish the relative chronology of large "dated-craters." If sudden changes in the impact flux of 1–10 m bodies (producing 100 m-diameter counter craters) remain smaller than the subsequent net cratering record, then the areal density of these craters can establish the relative age of the larger dated craters. If changes in the counter-crater production rate approach the subsequent cumulative cratering record, however, then gaps and clusterings in the distribution of inferred ages of the larger dated craters instead could refer to changes in the production of smaller counter craters. Either interpretation is significant for recognizing changes in the impact flux.

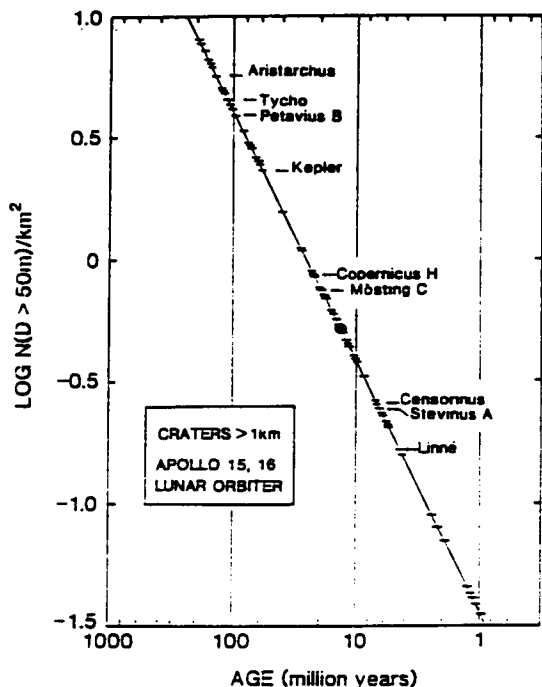
Approach: Previous studies have concluded that the impact flux on the Moon over the last 1–2 billion years has been reasonably constant (4), but sudden changes in the impact flux over time intervals as short as 30 my could not be detected in these studies unless the added crater population greatly exceeded the cumulative cratering record. Consequently this study focuses only on bright-rayed craters larger than 1 km thereby not only limiting the study to recent craters but also largely eliminating contamination by secondary craters. Preservation of ray patterns and other fine-scale surface textures in the ejecta provides first-order culling of craters younger than Tycho, i.e., about 100 my. Cumulative size-frequency distributions of small craters (20–60 m) superposing 10 selected craters including sample-dated craters (South Ray, North Ray, and Cone Crater) established very similar power-law distributions between -2.9 and -3.1 and the statistical significance of relative age differences. The distributions were then used to normalize the counter-craters to a common diameter ($D = 50$ m) for 60 additional craters selected from Lunar Orbiter and Apollo photographs. The normalized counter-crater density for craters sampled and dated during the Apollo missions then provided calibration for estimating absolute ages of the dated craters.

The degradation of radar haloes around recent lunar craters may provide a separate assessment of the distribution of crater ages. The freshest lunar craters exhibit a broad 3.8 cm radar halo extending up to 30 crater radii from the impact (6, 7). The diameter of the radar halo decreases with crater age, an effect that is largely independent of terrain (mare vs. highlands). This data set encompasses most of the lunar nearside whereas craters dated by the statistics of small superposed craters are restricted to Apollo and Lunar Orbiter coverage. Overlap in the two data sets permits calibrating the change in the relative size of the radar halo with time. The derived calibration yielded a correlation coefficient better than 0.95 over inferred ages from 1 to 100 my. Restricting the selection of craters to diameters from 2 to 15 km limited possible scaling effects in the processes responsible for the radar halo and eliminated craters near the resolution limit.

Results: Figure 1 reveals that dated-craters exhibit distinct clusters and gaps in the density of the superposed counter craters. In absolute time, there is an inferred increase in the production of craters larger than 1 km at around 60 ± 10 , 20 ± 5 , 15 ± 5 , 7 ± 1 my with an additional spike between 1 and 2 my. If only craters larger than 2 km are considered, then times of increased cratering occur at about 65 ± 3 , 15 ± 5 , and 6 ± 2 my. If normalized to a common time interval, however, only the enhancements at 2, 7, and 15 could be considered significant. These ages are only preliminary and depend on calibrations with sampled-crater ages, but they serve to illustrate that a non-random impact flux emerges from the data. If the significance alternatively should focus on the counter craters, then the paucity of dated craters between 7 and 12 my would reflect a sudden increase in the flux added to the background random flux at about 7 my. Such an increase would have to exceed 15 times the time-averaged rate if limited to a time interval of 1 my. The gap between 20 my and 60 my would require an increase exceeding 60 times the time-averaged flux if concentrated in a 1 my time interval. The derived time-averaged impact flux producing craters larger than 50 m is about $4/\text{km}^2/100$ my whether referenced to Tycho, North Ray, Cone, or South Ray craters, thereby supporting previous conclusions that the cumulative flux of objects producing small craters has been reasonably constant over long time intervals (i.e., the last 0.1 to 1.0 by).

The age-calibrated radar-haloed craters provided 90 craters larger than 2 km on the lunar near-side of which 15 were also in the set of 38 craters dated by crater statistics. Well-defined clusterings in ages were found at 6 ± 2 my and 15 ± 2 my with inferred enhanced flux rates six times higher than average. Craters with inferred ages near 6 my tightly cluster in the eastern lunar hemisphere, whereas the 15 my group broadly cluster in the western hemisphere. In contrast, craters older than about 100 my are largely confined to the eastern nearside.

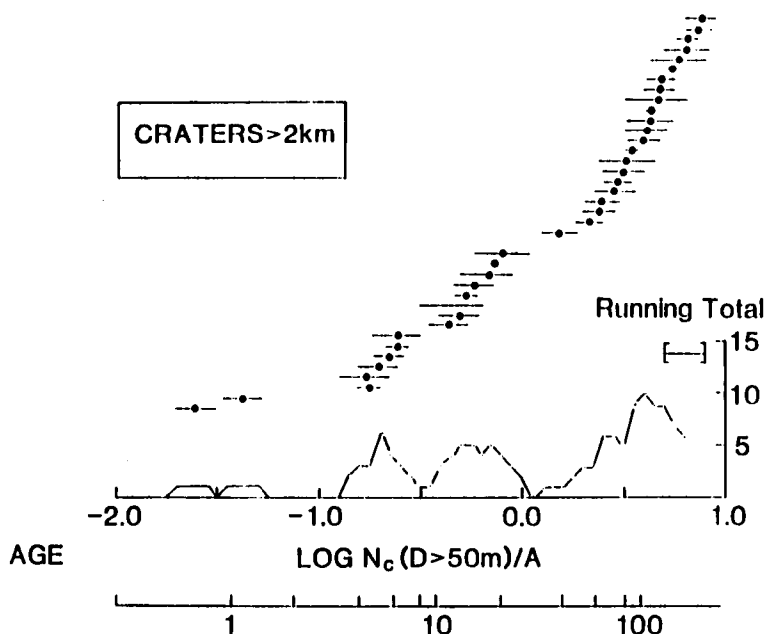
Conclusions: Although a periodic change in the impact flux in the Earth-Moon system cannot yet be confirmed from the data, a non-random component appears to exist with an increased flux around 7 and 15 my. The concentrations in different quadrants of the lunar hemisphere would be consistent with a shower of debris generally smaller than 0.5 km.



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Figure 1. Distribution of dated craters larger than 1 km calibrated from the sampled dates of Tycho (5), North Ray (8), South Ray (8), and Cone (8) craters.

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Figure 2. Histogram of dated craters larger than 2 km shown as a running total. Individual data with statistical error bars are shown above.



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