
Size-frequency distributions of lunar craters are being newly determined to estimate more accurately the populations of primary impacting objects in different time periods over a wide size range and to establish the frequency distributions characteristic of secondary craters of basins. The impetus for this work is the recognition that many craters previously thought to be of primary impact or internal origin are basin secondaries (refs. 3,4).

We are reclassifying by age, origin, and size all conspicuous craters > 4.5 km diameter in the nearside area covered by 1:1,000,000-scale LAC charts and all > 20 km on the rest of the Moon. Only craters with sufficient exposed rim to establish identity as craters beyond doubt are included. Highly irregular craters are not included, even if classifiable, because of measurement uncertainties. Results are reported here for 2589 craters in a LAC area of 9.63 x 10^6 km^2 for the two age categories Copernican + Eratosthenian (C + E) and Imbrian and for the genetic categories primary impact and secondary impact. Preliminary results for Nectarian primary craters outside the LAC area also are discussed.

Ages were assigned, where possible, by means of superposition relations with units whose stratigraphic position has been established by the USGS lunar mapping program. For C + E craters, this was possible for about half the LAC area. C + E craters in the terra were identified by densities of small superposed craters and by morphologic comparisons with those superposed on mare materials, with allowance for some degradation of fine features. The lower age limit of most Imbrian craters was directly determined by superposition relations with Imbrium basin units; the upper age limit was directly determined for craters in contact with mare material and indirectly by morphology and density of superposed craters.

Genetic classification is based on morphology and spatial distribution. Orientale secondaries begin to be numerous at one basin diameter (930 km) and are identified out to 2000 km from the basin center by interference features, radial ejecta, clustering, overall radiality of groups, shallowness, and rim irregularities (ref. 4). Imbrium secondaries are concentrated from 1250 km from the basin center to the limit of the study area 3300 km from the center and are identified by dense clustering, radiality, and analogy with the better preserved Orientale secondaries. Where distinguishable, the small circular components of compound secondary craters are the diameters measured. Many of the large diameters reported here (and in other literature in which origins are not distinguished) might have been produced by multiple impacting objects. Primary impact craters that formed by multiple impacts also were identified by their interference features.

Crater frequency data were grouped and plotted incrementally (Fig. 1) according to the method given by Chapman and Haefner (ref. 1). Size-frequency data were first examined over different ranges and different size intervals and were fitted to power functions. Correlation coefficients based on the
standard error of the frequency of craters at diameter D were used to
determine which of the candidate power functions best fit the data set being ex-
a mined. The best fits for incremental plots are shown in Fig. 1; the corre-
 respond ing power functions and correlation coefficients (r) are stated below. The
data were then cumulated over the same size intervals and plotted in Fig. 2.

The slopes for both classes of primary craters younger than the Imbrium
basin—hence fresh-appearing—are similar. Reliable data extend only up to
about 70 km diameter. C + E craters smaller than 70 km (out of a population
of 631 craters in 9.63 x 10^6 km^2) are characterized by an incremental frequency
distribution \( N = 8.01 \times 10^{-4}D^{-0.42} \) (r=.98). For 488 Imbrian primary craters
in 4.40 x 10^6 km^2, the best fit of the data gives a frequency distribution of
\( N = 1.24 \times 10^{-5}D^{-2.37} \) (r=.98). The 1.5-times greater density of Imbrian cra-
ters suggests a 6.5-times greater rate of formation than for the C + E craters,
taking the Imbrian Period at 0.75 ± 0.1 x 10^9 yr and the C + E at 3.2 ± 0.1 x
10^9 yr (based on work in progress by Wilhelms and J.M. Boyce).

Preliminary plots of 587 Nectarian primaries > 20 km in 12.15 x 10^6 km^2
in the east and central far sides show a break in slope at about 50 km diameter
(not illustrated here). Below this size they have an incremental frequency of
\( N = 9.7 \times 10^{-4}D^{-1.93} \) (r=.99) and above 50 km, \( N = .82D^{-3.50} \) (r=.92). This
tentative finding supports earlier results for the Moon, Mars, and Mercury
(ref. 3) indicating that primaries grouped without consideration of age were
deficient below about 50 km compared with an extrapolation of larger craters
to smaller sizes.

Basin secondaries are by far the most numerous type of crater between 4.5
km and 20 km in the highlands. In a central highlands area of 1.202 x 10^5 km^2
(lat 2°S - 4°S, long 6°W - 26°E) in which all craters (1428) > 4.5 km were
tabulated, there are 106 C + E primaries, 112 Imbrian primaries, 94 Nectarian
primaries, 60 pre-Nectarian primaries, 943 Imbrium basin secondaries, and 113
craters of other or unknown origins or ages.

The incremental size-frequency distribution of 1173 Imbrium secondaries
(a set partly overlapping with the set of 943) in a southern highlands area of
4.40 x 10^6 km^2 is \( N = .02D^{-3.07} \) (r=.97) (Fig. 1). For 297 typical Orientale
secondaries in an area of .514 x 10^6 km^2 within 3800 km of the Orientale center,
\( N = .13D^{-3.66} \) (r=.91). In addition, an excess of craters smaller than 10 km
and morphologically like Imbrian primary craters forms an Orientale"ray" along
the southern edge of the LAC area.

The frequencies reported here for C + E, Imbrian, and Nectarian primaries
are production populations. These craters are widely spaced and do not have
the -3.0 incremental frequency slope characteristic of saturation (as defined
in ref. 2) in the sizes measured. Pre-Nectarian primaries superposed on some
pre-Nectarian basins on the far side are also production populations but local
saturations do occur in this age category. For basin secondaries, the degree
of saturation is highly variable and has no age significance. Some basin
secondaries are spaced far apart (and hence are not always identifiable),
whereas others are densely packed and have swamped one another to a state far
exceeding saturation. For Imbrium secondaries, saturation may be reflected by
the -3.07 incremental-distribution slope and the turndown at small crater
sizes. Orientale secondaries in most of the count area are more widely spaced,
and their -3.66 slope might more nearly reflect the production population.
PRIMARY AND SECONDARY CRATERS


BOTH FIGURES
Plots top to bottom:
Orientale secondaries
Imbrium secondaries
Imbrian primaries
C + E primaries

Figure 1. Incremental (ref. 1).
Figure 2. Cumulative.

References