PRIMARY, SECONDARY AND TERTIARY MICROCRATER POPULATIONS ON LUNAR ROCKS; EFFECTS OF HYPERVELOCITY IMPACT MICROEJECTA ON PRIMARY POPULATIONS.

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Since return of the first Apollo lunar samples, the definition of the primary cosmic dust impact microcrater distribution on lunar regolith materials has been a prime research objective. Well documented model crater populations have been measured on 60015 [1] and more recently on 12054 [2] representing an extensive and carefully executed observational achievement. We now ask how valid these models are; in particular how are such observed models related to the true primary crater distribution. A newly completed computer program presents calculations of secondary and tertiary microcrater numbers expected to be formed by each of these two model microcrater distributions. Basis for the work is experimentally measured secondary *hypervelocity* impact craters formed from laboratory impacts on lunar rock. Previous laboratory measurements have been made of submicron impact spallation ejecta [3] and secondary hypervelocity microcraters [4] produced near impacts of 4-6 $kms^{-1}$ iron microspheres on lunar crystalline rock (62235). It has been suggested that accreta and hypervelocity microdebris could be more significant in the development of lunar microfeatures smaller than 100μm than would be indicated by previous downward extrapolations [5] from centimetre scale laboratory hypervelocity impacts (e.g. [5], [6]).

New measurements and calculations indicate situations where important secondary and in some instances even *tertiary* microcrater populations are formed from line of sight recapture of the hypervelocity ejecta component above the lunar escape velocity, integrated from sites up to the lunar horizon. Particularly significant enhancement is expected of secondary impact microcraters on surfaces with partially enclosed geometry (e.g. populations inside hemispherical impact pits or clefts). Measured microcrater distributions from Apollo 60015 and the particularly well orientation documented sample 12054 are depicted in Figures 1 and 2 respectively. Convolutions of each of these distributions with the secondary microcrater production profile measured by [7] yields secondary lunar microcrater distributions for 100% recapture environments; a second convolution yields the tertiary distribution.

Upper size limits have been imposed on the assumed primary crater distribution calculations. These represent the situation within a host crater which has been exposed to the incoming hypervelocity particle flux for sufficient time to build up an interior microcrater family up to and including each size. Figures 1 and 2 show these calculations for 10, 100 and 1000μm upper limits for the 60015 and 12054 model distributions.

Secondary microcraters of any given size are generated from a range of primary crater sizes and the relative numbers contributed are a function of both the assumed primary distribution and the secondary ejecta crater production. Table 1 shows these relative contributions for the 12054 model distribution limited to below 1000μm. Surprisingly *tertiary* populations can exceed secondary ejecta populations on a submicron size scale for both sample primary input distributions. Chiefly because of the differing slopes of these observed distributions for craters in the hundreds of microns size region, calculated numbers of ejecta impact craters can become comparable with the observed microcrater distribution over different size ranges for the 60015 and

PRIMARY, SECONDARY AND TERTIARY MICROCRATER POPULATIONS...

R. P. Flavill et al.

12054 curves. For the input distribution of Fechtig et al. [1], secondary <u>and</u> tertiary populations can exceed the primary populations at < .1μm crater diameter. For the input distribution of Morrison & Zinner [2], secondary populations only can exceed the primary populations over the range 1 - 10μm crater diameter.

Practical exposure geometries imply reductions in secondary microcrater populations due to capture efficiency less than 100%. For a perfectly flat surface (not within a crater pit) parallel to the lunar surface, the secondary and tertiary crater populations are near to zero. For the vertical sides of a rock, the primary population is reduced by 50%; the capture solid angle of 50% for non-primary impacts for this surface thus leads to an equivalent situation to Figures 1 and 2 (representing 100% capture) but with all numbers of craters reduced by a factor of two. Conversely an enhancement of the calculated *local* capture of secondary populations is expected due to the circumstances of the secondary cratering experiment [4]. In this experiment hypervelocity debris from micron scale impacts on the rough surface must have already been partly locally captured and therefore escaped detection.

Work will continue to evaluate the secondary and tertiary crater population for arbitrary sample exposure angles.

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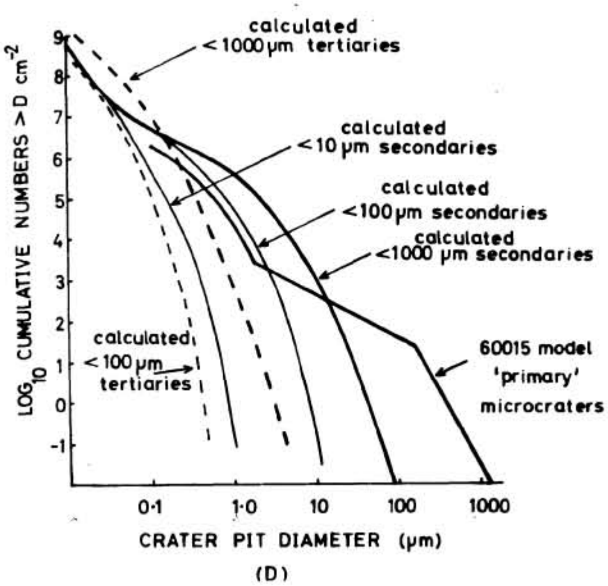


Fig. 1. Calculated secondary and tertiary microcrater populations from 60015 model [1] input distribution limited to below 10, 100 and 1000μm.

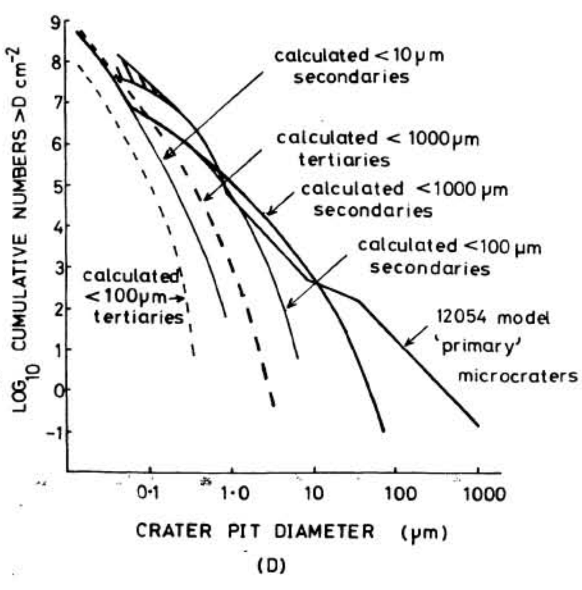


Fig. 2. Calculated secondary and tertiary microcrater populations from 12054 model [2] input distribution limited to below 10, 100 and 1000μm.

| Primary Crater Median Pit Diameter in µm. | Secondary Crater Median Pit Diameter in µm | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 31.62 | 10.00 | 3.16 | 1.00 | 0.32 | 0.10 | 0.03 | 0.01 |
| 1,000.00 | - | - | - | - | - | - | - | - |
| 316.23 | | 1.00 | 0.53 | 0.26 | 0.04 | 0.02 | - | - |
| 100.00 | - | - | 0.47 | 0.39 | 0.36 | 0.06 | 0.03 | - |
| 31.62 | - | - | - | 0.35 | 0.54 | 0.58 | 0.09 | 0.01 |
| 10.00 | - | - | - | - | 0.06 | 0.11 | 0.11 | 0.00 |
| 3.16 | - | - | - | - | - | 0.23 | 0.39 | 0.05 |
| 1.00 | - | - | - | - | - | - | 0.38 | 0.08 |
| 0.32 | - | - | - | - | - | - | - | 0.86 |
| 0.10 | - | - | - | - | - | - | - | - |

Relative numbers of secondary craters of various pit diameters due to primary craters of pit diameters less than 1000µm, based on 12054 data [2].

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