MICROPARTICLE HYPERVELOCITY IMPACT COMMINUTION DISTRIBUTIONS, PRIMARY CRATER AND ACCRETIONARY POPULATIONS ON LUNAR SAMPLES.

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Introduction: The lunar surface and lunar samples have been studied extensively for their evidence of hypervelocity impact from interplanetary matter; such craters can be identified without difficulty and population distributions derived for both young 'production' surfaces and older 'equilibrium' surfaces(1,2,3). The role of ejecta and communication products from such impacts has been recognised as the prime material for regolith development but on a microscale the role of ejecta has attracted less attention to date despite its very significant effect on lunar sample surfaces and measurements. Such importance of accretionary particles is simply highlighted by their higher spatial density than primary impact craters(4,5). We have studied lunar samples to characterise and interrelate further the primary crater and secondary particle distributions and subjected lunar samples to experimental hypervelocity impacts to establish typical comminution distributions.

Measured Microcrater Populations, Secondary Craters and Accretionary Particles: Observations were performed using an SEM identifying firstly primary impact craters. Results(shown with other data in Fig.5) refer to sample 60015.6 are in close agreement with other data; the sample exposure age is reported as 1.5×10^5yrs(2). Care was taken to distinguish at micron dimensions between primary craters and other craters of very similar appearance but much shallower. A family of such features were identified as the micron component of the familiar glass splashes seen at larger dimensions. Surface tension is sufficient to retain circularity at these dimensions; we estimate their impact velocity to be $\lesssim$1 km.sec. by the absence of a depression which would result from exceeding the rock crushing strength. A further class of particles was observed - accretionary debris characterised by angular features and not associated with any significant impact damage. Such distributions have been previously reported(4) and found to be variable in extent. The particles are nevertheless firmly attached and do not result from contaminants introduced during handling. We now report an experiment performed to generate such debris.

Experimental Production of Impact Comminution Products: A series of experiments was performed using the 2MV accelerator of the MPI Heidelberg. We report the first of such analysed using an experimental arrangement as shown in Fig.1. The surface of sample 62235,28 was exposed to 2840 particles selected to a velocity range of 3 to 6 km.s^{-1} and of mass 10^{-11}grms. The sample is a cataclastic anorthosite with an average grain size of one millimetre. A polished glass collection surface was placed nearby and the surface subsequently examined by SEM at 5 selected areas. No splashes or hypervelocity damage was observed, but a large quantity of fragmental and jagged particles were detected and measured, of appearance indistinguishable from the actual accretionary fragments on sample 60015. The impact velocity is estimated as $\lesssim$.5 km.s^{-1} for the bulk of this

material. We show in Fig.2 the size distribution at different elevations from the surface. The greatest flux is observed at high elevations in line with data of Gault(6) and Eichhorn(7). We note, however, the significant fraction at low elevations, which due to the large solid angle integrates out to form the greatest mass contribution(Fig.3). The impact distribution at 4 km.sec.^{1} is scaled by an energy relationship of Gault(8) to an anticipated lunar impact velocity of 20 km.sec. to derive the normalised comminution distribution integrated over 2π steradians(Fig.4). Assuming a size invariant or weak scaling of such a distribution, the results can be extended to dimensions outside the measured range. It should be noted that for a single crater of spall diameters of dimension d microns, the number of secondary particles exceeds unity for dimensions of $\lesssim d/4$. This comminution distribution is then applied to the observed primary crater distribution of sample 60015 to predict the accreta distribution which would result(Fig.5).

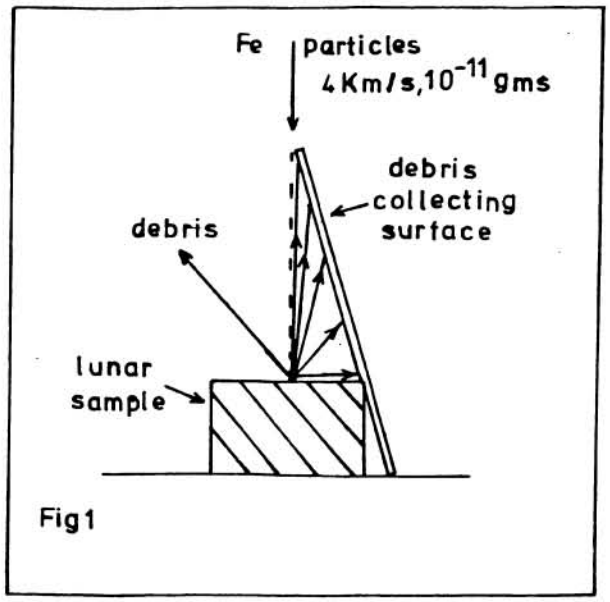

Fig 1

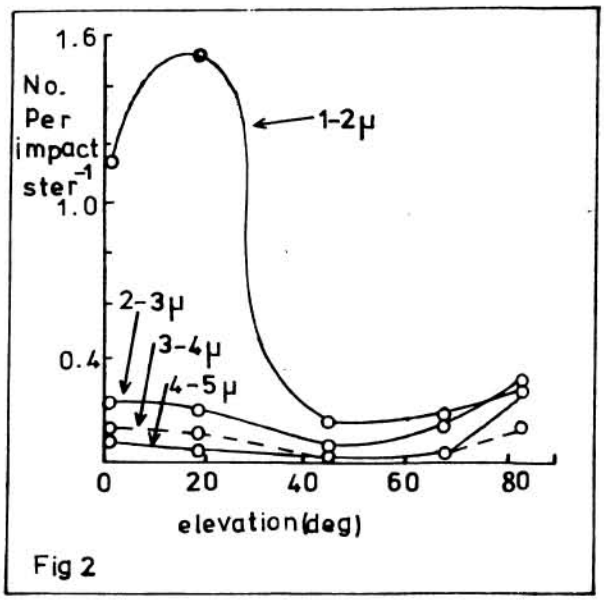

Fig 2

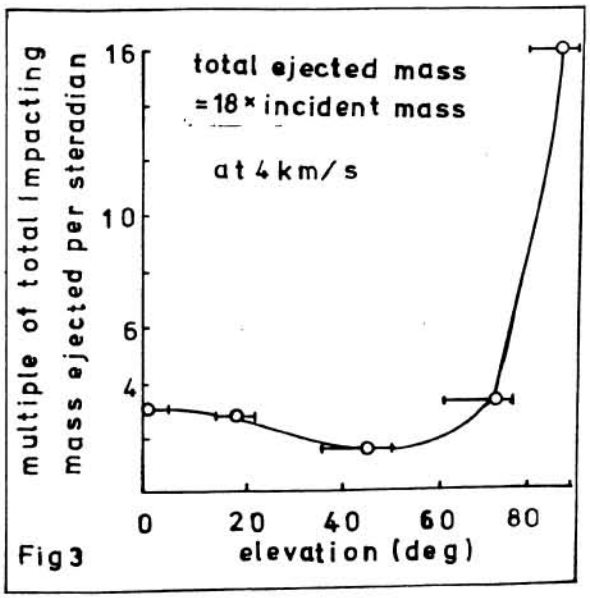

Fig 3

Conclusions: Although the primary impact crater distribution remains the major microscale erosionary force such populations are small compared to secondary particles and debris. We have experimentally measured a

comminution distribution for lunar samples which leads to ejecta densities very close to the observed densities. This shows the predominant role played by low velocity lunar ejecta generated at a flux rate up to an order of magnitude greater than the primary influx, and at elevations close to the lunar surface. As a contribution to microparticle transportation the mechanism could be invoked to explain the high surface activity observed on the LEAM micrometeoroid experiment.

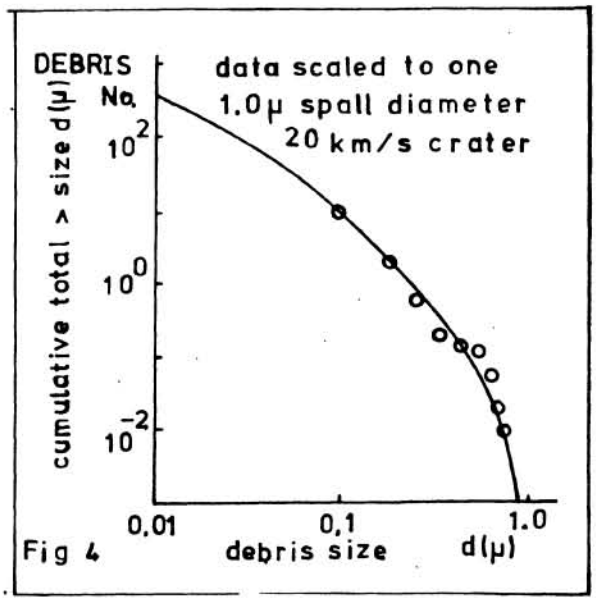

Fig 4

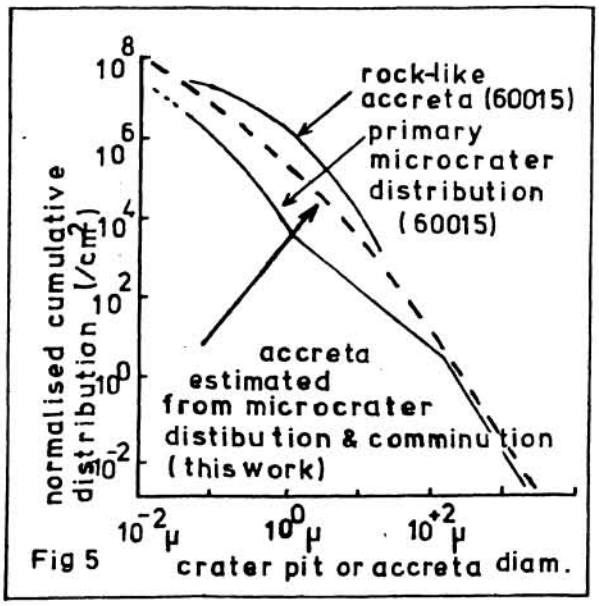

Fig 5

Acknowledgements: We thank H.Fechtig for use of the MPI accelerator, Heidelberg; the Science Research Council for financial support and Miss D. Paine for manuscript preparation.

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