LARGE SCALE BOMBARDMENT HISTORY OF LUNAR HIGHLANDS: A MONTE CARLO MODEL. F. Hörz, R.V. Gibbons, NASA Johnson Space Center, Houston, Tx 77058; R.E. Hill, LEC, Aerospace Division, Houston, Tx 77058; and D.E. Gault, NASA Ames Research Center, Moffett Field, Ca 94035.

A large variety of impact-related aspects concerning the lunar regolith have recently been explored via probabilistic computations, in particular via Monte Carlo computer techniques. This report utilizes many of the techniques developed in the above models; however, it employs a crater population of craters > 0.8 km diameter. Thus, it attempts to simulate the early bombardment history of the lunar crust. Though some of the basic input data must unfortunately remain model dependent , such modeling nevertheless appears well-suited for gaining qualitative insight into some aspects of the moon's early bombardment history; e.g., how often and to what depth was any given surface point cratered. Implications of such insight may include surface geology,geophysics, petrography, and geochemistry.

A first order problem is the input of a proper "production" crater size frequency distribution population. For structures ranging from 0.8 to 15 km in diameter, the crater counts of (1) were taken because they were predominately observed on mare basalt surfaces and ,thus, reflect a genuine production population. Structures > 15 km, however, must be observed in lunar highland terrains and it is uncertain whether genuine production populations can be obtained at all. Most likely, the crater populations presently observed are partial or complete "equilibrium" populations (1,2,3). For the latter, increasingly smaller crater structures would be progressively more depleted with the result that our model will underestimate their contributions. Keeping these qualifications in mind, the highland crater size frequency of (2) was used to represent the relative frequency of craters > 15 km in diameter. The mare statistics of (1) were normalized to the highland data of (2) at 15 km diameter. The probability of occurrence for any given crater size was calculated from this size frequency distribution according to the procedure of (4).

Another important model dependent parameter is the relation of present-day crater geometry to that of the transient cavity. This model uses the data of Dence (5) and Pike (6), which are thought to bracket the possible extremes in depth/diameter ratios; those of (5) will yield the deepest and those of (6) the shallowest depths of excavation. Because the data of (6) are based on present-day crater geometry, they will yield unrealistically shallow depths, and because no provision is made for wall-slumping, the model using (5) will give unrealistically deep depths of excavation.

The actual test surface represented a square that was subdivided into 27225 individual areal elements (cells). The computer continuously monitored the maximum depth (d_{max}) excavated per cell as well as how many times each cell was affected to depths d_{max}. The history of the volume excavated, i.e., the crater ejecta, was not traced and recorded at all; of interest was only the depression caused by a particular event. Immediately after any event, all cells affected were restored to the original "0" level and the next event occurred again on a level "0" surface. Thus, the model does not distinguish whether any given event occurs in pristine crustal materials or ejecta of previous impacts. This is immaterial for our prime interest, namely how often

any given surface point was impacted and to what depth, the latter always measured from the actual lunar surface, irrespective of topography.

Some representative results are illustrated in Figs. 1 - 3. Fig. 1 represents "time" versus average depth excavated. Because there is no means of assigning an absolute time frame for the moon's early bombardment history and because the early flux was not linear (1,2,3), an actual time parameter is not given; instead, "time" is expressed in fractions of the total bombardment energy with unity representing the observed, present-day crater number density. According to Fig. 1, the average depth to which the lunar surface was excavated is approximately 2.3 km for the crater model of Pike (Model A) and 11.4 km for the values of Dence (Model B). Fig. 2 illustrates how deep various fractional surface areas were cratered. Model A again corresponds to (6) and Model B to (5). Note that according to Dence's depth/diameter ratios approximately 10% of the lunar highlands are cratered > 40 km deep; 1% is cratered even deeper than 100 km. Finally, Fig. 3 represents how often various fractional surface areas are impacted as a function of "time". For example, the following applies to the present-day lunar highlands: 5% have been impacted at least 9 times, 50% at least 4 times, and 75% at least 3 times; approximately 2.5% of the surface area has remained unaffected by craters > 0.8 km. Since all craters penetrated at least 150 m, the number of impacts also correspond to how often the uppermost 150 m was turned over during the entire lunar bombardment.

These results must be considered preliminary because modification of the transient cavity, i.e., wall-slumping, was not considered at present; corresponding runs are in progress. Finally, calculations will be performed that produce larger numbers of craters than the observed cratering record, thus establishing constraints for hypothetical, even more intense, bombardment histories for the lunar highlands.

References:

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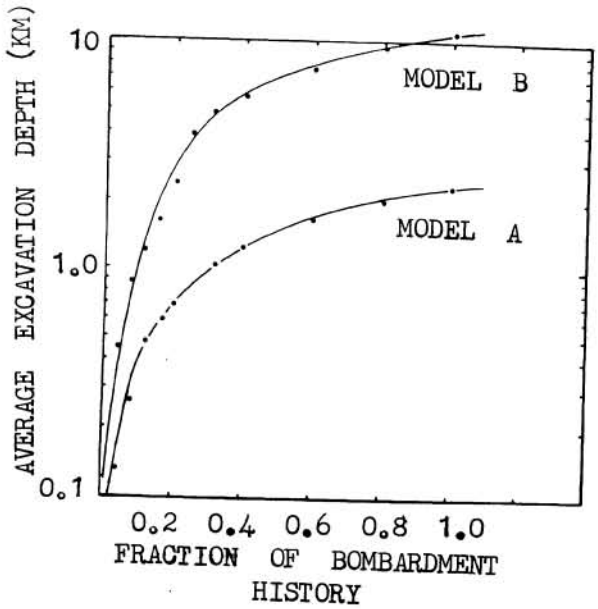

Fig. 1

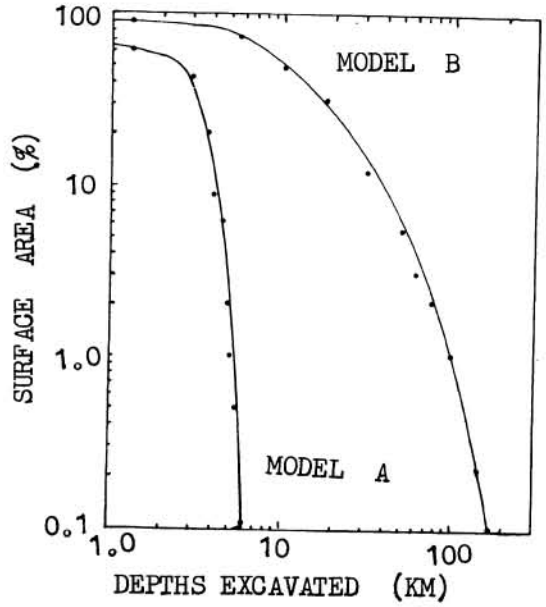

Fig. 2

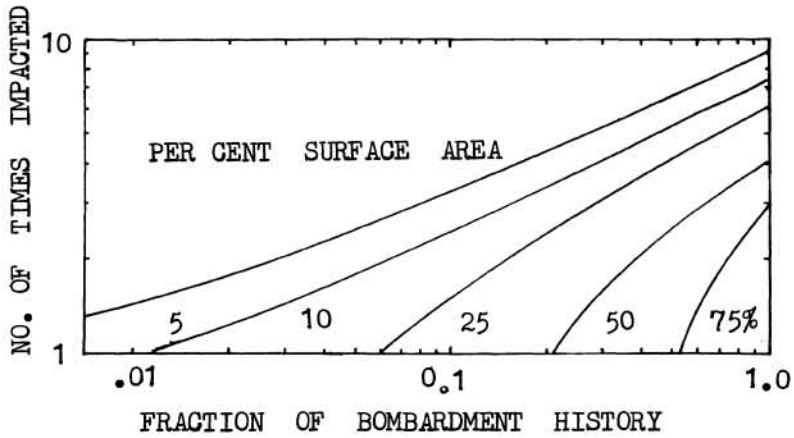

Fig. 3