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PROCESSING AND REDISTRIBUTION OF SURFACE AND SUBSURFACE SAMPLES BY IMPACT CRATERING; A. Woronow, Geosciences Department, University of Houston, Houston, TX 77004.

As a portion of the the martian surface becomes more densely cratered, the more the surface and subsurface materials become laterally redistributed and impact metamorphosed. This abstract characterizes specimen redistribution as a function of both impact density and original specimen depth, and also characterizes the impact histories of those specimens.

Method

An entirely new Monte Carlo simulation is being constructed along the lines of Cashore and Woronow (1985). It currently includes complex crater geometries (flat floor, inner rim, inward-sloping ejecta blanket, and exponentially decaying outward ejecta blanket) according to the parameters given by Pike and Davis (1985). Crater ejecta blankets extend to five radii from the crater center and conserve excavated volume. This simulation utilizes a variable-size, gridded target surface with an evolving topography interpolated between the grid points. For this study, the surface is 1500 km by 1500 km with 256 grid points.

Crater diameters are selected at random from the production distribution function defined by Woronow, et al. (1982) for craters greater than 8 km in diameter. Crater centers are located uniformly randomly on the surface at the instantaneous local elevation. A zone around this target surface can receive impacts and spray ejecta onto the target surface, but data are not retained on that extended zone.

Tracer particles (representing possible "grab samples") may be placed on the surface or embedded in the subsurface. When excavated by an impact, the tracers are "entrained" in both the ejecta and the in-crater fallback. Repeated trials record the number of impacts sustained by each tracer and the tracer's total displacement.

Results

This abstract reports only on those tracers that, at the termination of the simulation, resided in an ejecta blanket rather than in the crater fallback.

For tracers starting from the same depth, as the cumulative crater flux (measured in multiples of the observed lunar highlands density, OLHD) increases, tracers tend to be spread increasingly farther from their original sites and to experience an increasing number of excavation/redistribution events. However, the displacement distance is only weakly related to the total impact flux, the median displacement for 1x OLHD being about 70 km increasing to only about 90 km for 3x OLHD (Figures 1a,b). The most distantly displaced tracers are not necessarily the ones that experience the greatest number of impacts. This is apparently because large, relatively rare, events at any flux dominate the lateral transport of tracers. Small craters are relatively inefficient dispersers of tracers because 1) they may not excavate to the tracers buried in an ejecta blanket or subsurface, and 2) in a random walk process like this one, the expected displacement is proportional to D n where D is the average step size and n is the number of steps. Concentrating on the second of these, the first having a rather obvious effect, we note that D increases linearly with crater (and ejecta) size whereas n depends upon the number of craters of size D. For the assumed production function, if we select D_1 to be 500 km and D_2 to be 10 km then n_1/n_2 is approximately 1000. Therefore, the ratio of D_1 n_1/D_2 n_2 shows that a single 500 km diameter crater, on the average, disperses tracers about 1.5 times farther than the combined efforts of the 1000 corresponding 10 km diameter craters!

Figures 2a-d show the number of impacts experienced by tracers initialized at a variety of depths and sustaining various cumulative impact fluxes. In Figure 2a and b, the solitary effects of increasing flux may be seen. Fewer tracers avoid impacts, and the average number of impacts experienced increases from 0.6 to 2.6 for an increase in the flux from 1x to 3x OLHD. As the initial burial depth of the tracers is increased (Figures 2c,d), while maintaining a constant 3x OLHD, the distribution of the number of impacts suffered almost reverts to one like that for a lower flux (compare Figures 2c,d with Figure 2a). However, very important differences exist. First, for shallow burials (e.g. 2 km in Figure 2c), although many tracers escape excavation, once excavated they sustain a greater average number of impacts than do samples originating at the surface of a terrain sustaining a lower cumulative flux. In addition, the tail of the distribution is extended to greater numbers of impacts experienced for the shallowly buried tracers (Figures 2c) than for the surface tracers under lower flux (Figure 2a). With even greater initial burial (10 km) and the same 3x OLHD (Figure 2d), this tail of the distribution diminishes; most likely this occurs because the mean time a tracer must wait to be excavated is greater and, therefore, it spends less time exposed near the surface.

Ignoring those tracers that are never excavated, surprisingly small differences occur in the average number of impacts experienced by tracers originating from 0, 2, and 10 km depth, namely averages of

3.1, 2.6, and 2.3 impacts per tracer (Figures 2b,c,d). Therefore, samples from a wide range of depths may have quite similar impact-metamorphism histories.

Conclusions: 1) Lateral transport of samples found at the surface is not highly correlated with the impact flux, but is dominated by the rare, large impact events. 2) Although specimens collected from higher-flux terrains will have been impacted more frequently (even if they came from depths of 2 km) than would specimens collected from lower-flux terrains, specimens originating at 10 km depth have an impact history more closely corresponding to that of the lower-flux terrain specimens. 3) For a single terrain, samples originating from greater depths will have suffered only a slightly lesser average number of impacts than those originating closer to the surface; therefore, the degree of impact metamorphism is not strongly correlated with the depth of origin of the specimens.

REFERENCES

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Figure 1: Displacement of tracers that have been excavated at least once. a) 1x OLHD. b) 3x OLHD.
Figure 2: 10 trials each of a) 1x OLHD, tracers at surface; b) 3x OLHD tracers at surface; c) 3x OLHD tracers at 2 km depth d) 3x OLHD tracers at 10 km depth.