

A STOCHASTIC CRATERING MODEL FOR ASTEROID SURFACES. J. E. Richardson¹, H. J. Melosh¹, and R. J. Greenberg¹, ¹Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721. Email: jrjrich@lpl.arizona.edu.

Introduction: The observed cratering records on asteroid surfaces (four so far: Gaspra, Ida, Mathilde, and Eros [1-4]) provide us with important clues to their past bombardment histories. Previous efforts to model these records have led to two basic styles. The first is to use Monte Carlo techniques [5] to stochastically populate a model surface with craters as a function of time [6,7]. The second is to use a parameterized approach to duplicate the statistics of the observed crater population [8,9]. In both methods, several factors must be included beyond the simple superposing of circular features: (1) crater erosion by subsequent impacts, (2) infilling of craters by impact ejecta, and (3) crater degradation and erasure due to the seismic effects of subsequent impacts. Here we present an updated Monte Carlo modeling approach, designed specifically for medium-sized asteroids.

Basic model description: The model uses six two-dimensional matrix layers to represent a asteroid surface: two layers to store crater diameter values, two to store ejecta coverage values, and two to store crater seismic damage values. The purpose for having two sets of information for each parameter is to permit the superposition of smaller craters on top of larger craters, while preserving the larger crater information. Each matrix element (pixel) represents a unit of surface area, such that to model the surface of 433 Eros (1125 km² [10]), each pixel represents a 20 m squared area, for a total surface area of 34 km squared (1156 km²). The model surface possesses periodic boundary conditions to produce a continuous cratering surface.

Impactors and resulting craters: The impactor population used in the model represents the average population of asteroids present in the Main Belt, based on the collisional modeling described in [11]. Impactor sizes range from the size needed to produce a crater equal in diameter to one pixel, up to the size of impactor capable of disrupting the asteroid [12, 13]. Impactor sizes are then mapped to final crater sizes by multiplying the impactor diameter by 30, employing a 'cube-root' crater scaling-law [14]. The resulting crater sizes fall into the transition region between strength- and gravity-dominated cratering [15].

Crater erosion by superposing impacts: New craters frequently superpose themselves on preexisting craters, with the underlying, older craters eventually eroded and erased by this process. In the model, a size constraint is adopted such that for a small crater to erase a portion of a larger crater via superposition, the smaller crater must be at least 1/10 the size of the larger

one. Otherwise, the small crater simply rests on top of the larger one without affecting it. That is, it takes a new impact on the same size scale as the old one to erase a portion of an older, larger crater. This method is based upon the principle of impact gardening [12] and the crater erosion work described in [16].

Crater Erasure by Ejecta Infilling: Whenever a new crater is formed, the area within about five crater radii of the crater's rim is covered by a layer of impact ejecta, which can accumulate, fill in, and eventually erase impact craters. The model calculates an approximate ejecta blanket thickness, as a function of distance from the crater's rim, which is added to the cumulative ejecta thickness recorded in each pixel. If enough ejecta has accumulated since the formation of a particular crater, such that the crater would be completely filled, the crater is considered filled or erased.

Crater Erasure by Seismic Shaking: If a new crater's impactor is large enough--generally a few meters in diameter--to cause 'global' seismic effects on the asteroid, then all preexisting craters will suffer some amount of seismic damage, as described in [17]. That is, the craters is slowly eroded and in-filled through the downslope flow of regolith. If the total amount of seismic damage to a particular crater exceeds the amount that would allow it to remain visible, then the crater is considered filled or erased.

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