A FINITE-ELEMENT MODEL OF ASTEROID SURFACE EVOLUTION: SLOPE PROCESSES, CRATER CREATION AND ERASURE, REGOLITH GENERATION AND LOSS

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Introduction: Monte-Carlo cratering models have long been a mainstay in the study of cratered terrains. The majority of these models have been geometric in nature, with crater rims represented by circles in a 2D matrix, and employing mathematical functions to determine the effects of ejecta blanket coverage and the erosion of large craters by smaller ones [1,2,3]. The advantage of these simple models has been speed, with the ability to automatically compile crater-count statistics at each time step. Hartmann *et al.* [4] extended these techniques into three-dimensions to produce realistic topography, but required manual crater-counting of the synthetic images produced.

In this work, we present a new Cratered Terrain Evolution Model (CTEM) which utilizes recent advances in the impact cratering scaling-laws [5,6] and our understanding of seismically-induced crater degradation [3] to produce a fully 3D, finite-element model of crater production and erosion on a given (airless) target surface, which includes regolith generation, downslope regolith migration, and automatic crater counting.

Downslope Regolith Migration: A key feature of the CTEM is the inclusion of downslope regolith migration, triggered either by slope instability or by the seismic motion generated by nearby impacts. Following each impact event, the resulting regolith motion is computed in Eulerian fashion, using the slope degradation theory described in [3].

Crater Superpositioning and Erasure: In general, impact craters on airless bodies are erased by three mechanisms: subsequent impacts, which erode and modify the underlying crater; coverage by the ejecta thrown up by other, nearby impacts; and the downslope movement of regolith due to slope instabilities and impact-induced seismic shaking. The CTEM includes 12 layers which track a vertical "stratigraphic column" at each point within each crater produced. If a pixel-element of the crater is either excavated by a subsequent impact or eroded by downslope regolith motion, than that portion of the crater is considered to be "erased" and no longer tracked.

Model Application: The primary purpose of this model is to determine the local seismic effects of an impact on nearby crater morphology, particularly for the well-studied asteroid 433 Eros, and to refine the more generic, "global" seismic effects described in [3]. The model is well suited for other problems as well, such as asteroid regolith generation and impact history studies.

References: [1] Woronow, A. (1978). *Icarus*, **34**, 76-88. [2] Chapman, C.R. & McKinnon, W.B. (1986). *Satellites*, Univ. Arizona Press, 492-580. [3] Richardson, J.E., *et al.* (2005), *Icarus*, **179**, 325-349. [4] Hartmann, W.K. & Gaskell, R.W. (1997). *Meteoritics and Plan. Sci.*, **32**, 109-121. [5] Holsapple, K.A. (1993). *Ann. Rev. Earth & Plan. Sci.*, **21**, 333-373. [6] Richardson, J.E., *et al.* (2007). *Icarus*, **190**, 357-390.