THE INFLUENCE OF CRATERED SLOPES ON LATE-NOACHIAN VALLEY NETWORK FORMATION.

C. J. Barnhart[1,2], A. D. Howard[3] and J. M. Moore[1]. [1]SSD NASA Ames Research Center (MS 245-3), Moffett Field, CA, [2]Energy Resources Engineering, Stanford University, Stanford, CA (cjbarnha@stanford.edu), [3]Dept. of Environmental Sciences, University of Virgina, Charlottesville, VA

Introduction: Valley networks are widely distributed on the southern highlands of Mars [1]. Their distribution however is non-uniform [2-6]. The fragmental presentation of Martian valley networks is likely related to the nature of a cratered surface [3]. Flow paths are short and generally end in enclosed crater or inter-crater basins that would only overflow for high runoff to evaporation ratios. However, as pointed out by [3,6], establishment of long flow paths through fluvial erosion is enhanced by long and steep regional slopes. We use a landform evolution model to quantify the effect of regional slope and different initial surface morphology on the degree of valley network integration and incision.

Model: We seek to explore the effects that regional slope and impact crater basins have on valley network formation and integration. We employ the Mars Surface Landform Model (MSLM). MSLM is a suite of model components that simulate various geomorphic processes. Model components used in this work include fluvial erosion, eolian erosion and deposition, and mass wasting. Each of these processes change the height of elements that comprise a digital terrain model of a hypothetical surface.

For model mechanics, discussion of model limitations and assumptions, and details concencing the creation of model DTMs refer to [8,9]. The source code for the MSLM model and extensive documentation is freely available at http://erode.evsc.virginia.com.

Although crater rim slopes and other scarps can be much steeper, regional gradients on Mars at the scale of several hundred kilometers typically range from near zero to about 0.02 [10]. We simulated three regional slopes, 0.01, 0.001, and 0.0001. Similar to [9] we utilized a rectangular grid (256x512 cells, 0.5 km resolution) with the long axis aligned along the regional slope, with the bottom boundary as a drainage exit, the top boundary as a drainage divide, and the lateral boundaries being periodic.

We present three initial topographic conditions: 1) a tilted surface with low, fractal relief; 2) a simulated saturation cratered surface; and 3) a cratered surface degraded by local fluvial erosion under very arid conditions and mantled with moderate airfall deposits, simulating the fairly smooth, degraded Noachian surface hypothesized to have preceded the late stage valley incision (e.g., the reconstructed initial conditions surface in [8]). The smooth, tilted surface used as the first initial condition results in well-integrated fluvial networks similar to most terrestrial landscapes (e.g. [11]) and are a useful baseline to contrast the effects of cratered initial surfaces on reducing the depth and degree of integration of valley networks.

Results: Figure 1 shows three initial surfaces (top row) and the resultant surfaces after 1.5 million years of simulated fluvial geomorphic activity (bottom row). This activity was simulated using parameters that control stream discharge as a function of area and slope that are typical of the American southwest as identified in [7] and simulated by [8]. Eolian activity and lake formation are not simulated in the cases shown in the bottom row of Figure 1. All depressions are dry and do not overflow. The initial surfaces are characterized by a board regional slope with random variation (panel A); a surface saturated with impact craters (panel B), and a hypothetical mid-Noachian surface (panel C). Each surface has a slope from the top to the base of -0.01. The uncrated surface (panel D) shows deep incision and valley network integration throughout the domain. As shown in panel E, valley network incision is frustrated by topographic lows and drainage divides imposed by large impact basins. Short-length yet deep incision occurs on crater walls. The degraded, late-noachian surface (panel F) exhibits fluvial incision that links large crater basins together in a domain-scale fluvial network.

Conclusion: The distribution of valley networks on ancient Martian surfaces is widespread but not uniform. Low regional slopes, impact basins, and high evaporation rates frustrate valley network integration and deep incision. Valley network formation not only develops under a limited range of climatic conditions, but a limited range of morphologic conditions as well.

We will run simulations under a variety of precipitation regimes that permit lake development and overflow. The response to differences in initial conditions (particularly between the unmodified and pre-eroded cratered terrain) will probably be smaller under more humid conditions.

References: [1] Carr M. H. (1996) *Oxford* [2] Gulick V. C. (1998) *JGR*, 103 [3] Craddock R. A. and Howard A. D. (2002) *JGR* 107 [4] Harrison K. P. and Grimm R. E. (2002) *JGR* 107 [5] Stepinski T. F. and Stepinski A. P. (2005) *JRG* 110 [6] Irwin R. P. and Howard A. D. (2002) *JGR* 107 [7] Irwin R. P. et al. (2005) *Geology* 33 [8] Barnhart C. J. et al. (2009) *JGR* 114 [9] Howard A. D. (2007) *Geomorp.* 91 [10] Irwin et al. (2010) *LPSC* [11] Howard A. D. (1994) *WRR* 30

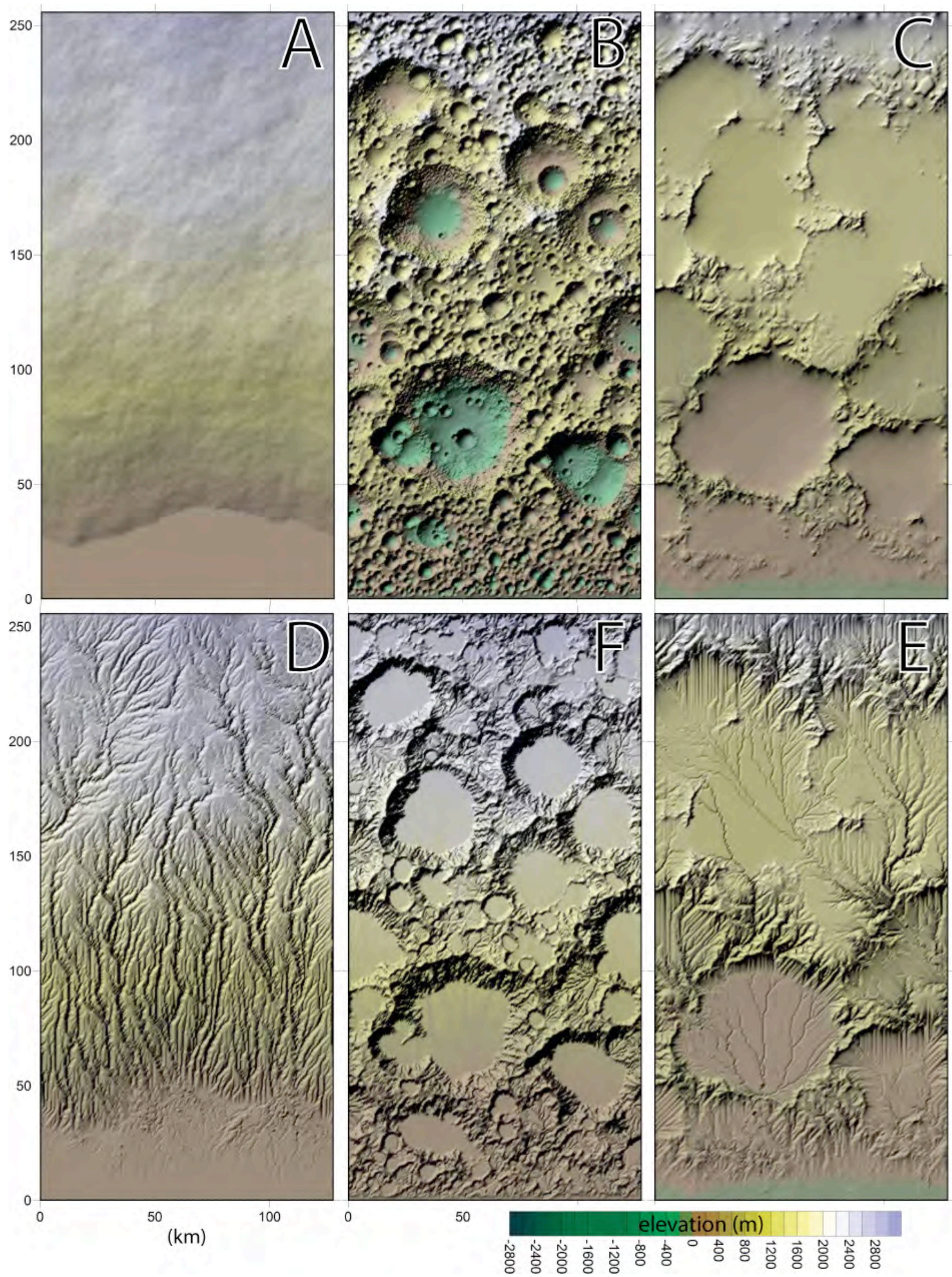

Figure 1: The top row shows the initial surfaces: a board regional slope (panel A), a surface saturated with impact craters (panel B), and a hypothetical noachian surface (panel C). Initial surfaces have the same slope from top to base of -0.01. Surfaces resulting from 1.5 million years of simulated geomorphic activity (bottom row) show that unmodified cratered landscapes frustrate valley network formation (panel E).