COMPUTER SIMULATION OF GROUNDWATER SEEPAGE WEATHERING IN FORMING MARTIAN VALLEY NETWORKS. Wei Luo[1] and Alan D. Howard[2], [1]Department of Geography, Northern Illinois University, DeKalb, IL 60115, wluo@niu.edu, [2]Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903, ah6p@virginia.edu

Introduction: The origin of Martian valley networks (VNs) has important implications for the hydrologic cycle and associated potential for life on Mars. Amphitheater-headed valleys on Mars, also characterized by short stubby tributaries, near constant valley width, U-shaped cross-section, low drainage density, and irregular longitudinal profile, similar to those observed in Colorado plateau [1], have often been attributed to erosion by emerging spring water (i.e., seepage erosion or groundwater sapping) rather than by surface runoff [e.g., 2-4]. This mechanism of valley formation would not require conditions warmer than the current cold climate. However, some more recent studies using higher resolution data have revealed the importance of fluvial surface runoff and by inference at least some precipitation on early Mars [5-7]. In addition, a number of studies have put uncertainties on groundwater sapping as the sole mechanism for forming the "typical" sapping characteristics [8-9]. This calls for careful evaluation of the evidences that support groundwater sapping origin of VNs. Computer simulation of landform development on Mars offers a valuable tool to explore the relative importance of groundwater vs. surface water in forming Martian VNs.

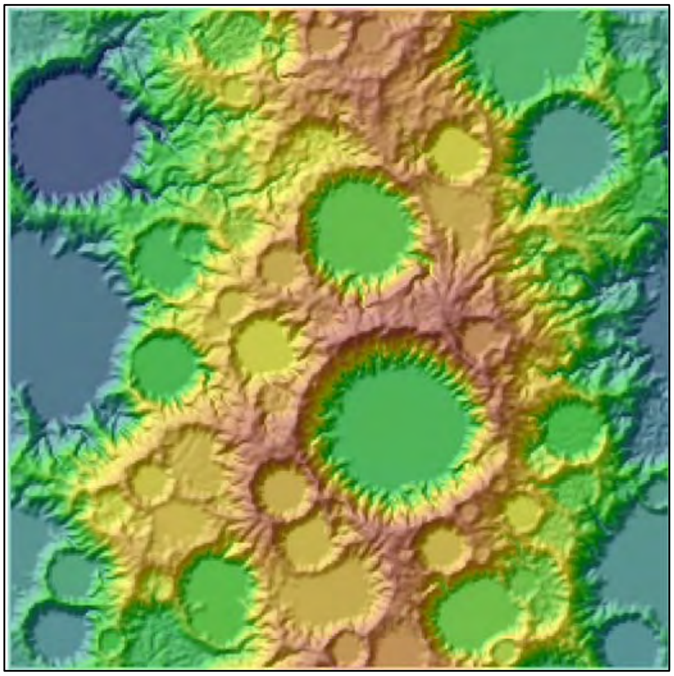
The Model: The computer model is developed by Howard [10-11]. It can simulate impact cratering, lava flows, eolian modification, and drainage basin processes, including weathering, mass wasting, fluvial erosion and deposition, and groundwater sapping [10-11]. We adapted the model to simulate the role of emerging groundwater on valley formation as seepage weathering, i.e., the emerging groundwater causes accelerated weathering of bedrock materials, which makes subsequent removal by other processes (could be discharged groundwater or surface runoff water from rainfall) much easier.

Preliminary Results: Figure 1 shows shaded relief images of four scenarios: (A) pure fluvial surface runoff erosion (no groundwater involvement), (B) both surface runoff and groundwater seepage, (C) pure groundwater seepage (all water comes from groundwater discharge), and (D) same as (C) but using end result of (A) as starting topography. Simulations (A)-(C) start with the same initial cratered terrain. For the pure fluvial surface runoff erosion (A), resulting VNs always respect the initial topography, similar to terrestrial fluvial valleys. For the simulation involving both surface and ground water (B), erosion is concentrated at low areas in the landscape - mostly starts in interior walls of large craters. Most seepage erosion becomes concentrated in a few large valleys that primarily extend headward and develop steep headwalls, forming the classic groundwater sapping pattern similar to those observed in Colorado Plateau [1]. For the case involving groundwater seepage only (C), the advanced headward erosion from opposite direction caused some crater walls to be breached. In both (B) and (C), the valleys that develop by seepage erosion can cross divides and basically "follow the water", in contrast to the fluvial erosion case that follows the topography.

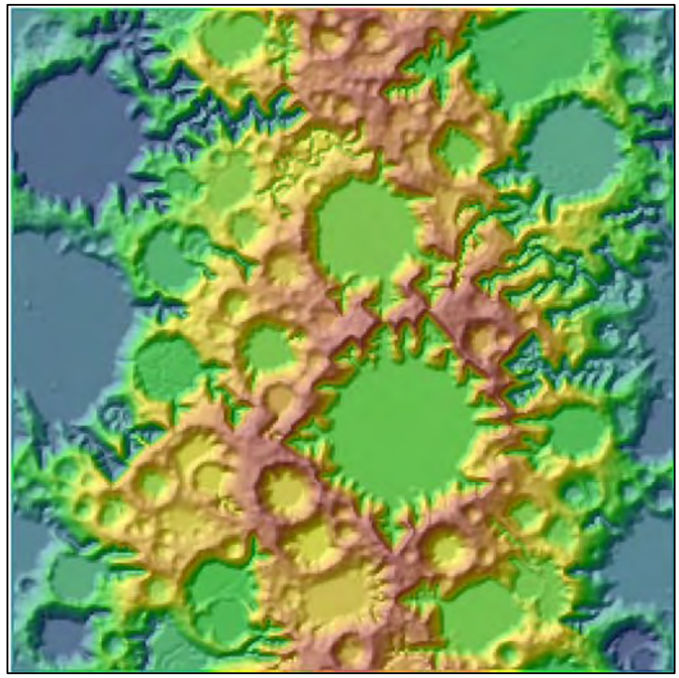
To test the hypothesis that some valleys may have been formed by a two-step process: started with fluvial erosion, then modified by groundwater sapping process [12-13], we use the end result of (A) as starting topography and run the simulation involving only groundwater. The result (D) shows that the pre-existing fluvial valleys provided easy access to groundwater flow and the seepage weathering and subsequent sapping widens these valleys, as well as extends them headward, forming a very dissected landform.

On-going and Future Work: Both surface and ground water were likely involved in Martian VNs. We are presently working on book-keeping the relative amount of rainfall water and groundwater contribution to surface flow and determine the relative importance of each source. We also plan to explore the effect of episodic wet spells over a generally dry climate, as suggested in [14-15], on VN morphology.

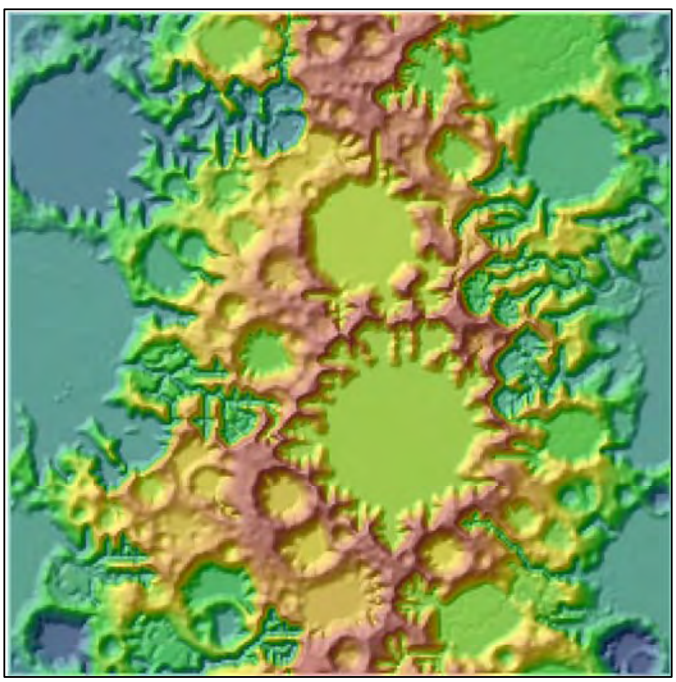
References: [1] Laity, J.E. and M.C. Malin, (1985), *GSA Bulletin*, *96*, 203-217. [2] Sharp, R.P. and M.C. Malin (1975) *GSA Bull. 86 (5)*, 593-609. [3] Pieri, D. C. (1980) *Science*, *210*, 895-897. [4] Carr, M.H. (1996) Water on Mars (Oxford Univ. Press). [5] Craddock, R.A. and A.D. Howard (2002) *JGR 107(E11)*, Doi:10.1029/2001je001505. [6] Mangold et al. (2004) *Science*, *305*, 78-81. [7] Ansan and Mangold (2006), *Planetary and Space Science*, *54*, 219-242. [8] Irwin, R. P. et al. (2006), *LPSC XXXVII*, abstract 1912. [9] Lamb, M. P. et al., *JGR*, *111*, E07002. [10] Howard, A.D. (1994) *WRR*, *30 (7)*, 2261-2285. [11] Howard, A.D. in preparation. [12] Baker, V.R. and J.B. Partridge, (1986), *JGR*, *91*, 3561-3572. [13] Williams, R.M.E. and R.J. Phillips, (2001), *JGR*, *106(E10)*, 23727-23751. [14] Stepinski, T.F. and A.P.Stepinski (2005), *JGR*, *110*, E12S12. [15] Howard, A.D. et al., (2005), *JGR*, *110*, E12S14. [16] Luo, W. and A.D. Howard, (2005), *JGR*, *110*, E12S13.



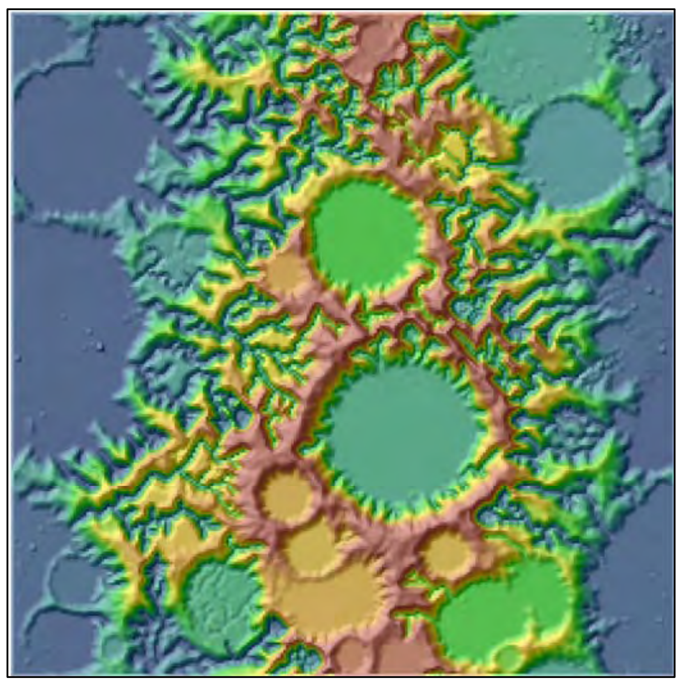
(A) Surface runoff only



(B) Both surface runoff and groundwater seepage



(C) Pure groundwater seepage (all water comes from groundwater discharge)



(D) Using end result of (A) as initial topography, pure groundwater seepage (all water comes from groundwater discharge)

Figure 1. Shade relief images of 4 simulation scenarios. Simulations (A) – (C) start with the same initial cratered terrain. The gradation of color from blue to brown indicates elevation from low to high.