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We report initial results in the development and application of software to simulate fluvial and ground water processes. The system utilizes a cellula automata approach and includes software objects to simulate system components and a software engine to drive the overall system as a function of time. The work builds on and extends such efforts as Chase [1], Koltermann and Gorelick [2], and Howard [3]. The intent is to develop the system, to understand the interactions among system components, to calibrate it in terrestrial hyperarid terrain (e.g. Kharga plateau and escarpment in Egypt, where extensive ground water sapping has occurred), and then to utilize the system to explore the development of martian channels and related features. We intend to explore two hypotheses, one that martian landforms and deposits were produced in a climatic regime in which surface conditions were at or above the triple point of water (i.e., there was surface water), and the second that they formed under a situation in which water was frozen at the surface and most physical and chemical aqueous activity was restricted to ground water and hydrothermal systems. System-wide modeling of topography, lithology, and stratigraphy is a critical and necessary step in understanding which hypothesis is valid and what observations and measurements would be needed to further test the model.

The software system is object-oriented so that system components can be replaced by new models that are more realistic than existing objects. For example, initial experiments incorporated a precipitation model [1] in which the amount of sediment eroded at a given position is equal to an erodibility times the maximum height difference in the local area. This object can be changed with the 2-D solution to the Navier-Stokes equations as given in [2]. In addition, the system includes as many components or objects as necessary in order to simulate the terrain realistically. Fickean diffusion is included as one system component to model the effects of landslides and soil creep. The Dupuit approximation is used to model ground water flow and sapping processes with erosion in proportion to discharge [3]. Flexure in response to the sediment load distribution is modeled as another system component using thin plate flexure theory [4] solved by Fast Fourier Transform techniques [5]. We are also exploring other components, such as dissolution kinematics of carbonate rocks and the formation of karst terrains.

We report on three experiments aimed at understanding interactions among different system components. First, the basic precipitation model [1] was coupled with the parameterized climate and flexure models to simulate the effects of wetter climatic conditions on landforms in mountainous areas on Earth. The simulations showed that a shift to more humid climatic conditions will lead to increased peak elevations, even without tectonic uplift. The reason, as intuited by Molnar and England [6], is that increased erosion produces deep valleys, whereas isostatic readjustment occurs over a finite flexural length scale. Thus, whereas mean elevation decreases, peak elevations actually increase. We also employed the basic precipitation model [1] in simulations in which eustatic sea level fluctuations were used to simulate the alluvial pediments and fluvial terraces along the Red Sea coast [7]. Eustatic controls on coastal landform evolutions are clearly manifested by the simulations. Third, a ground water sapping model for an unconfined aquifer using Dupuit assumption was applied to a structurally heterogeneous volume to simulate the landforms in Kharga region of Egypt. The model is primarily after [3], with the addition of erosion direction controlled by the direction of water table slope, and amount of erosion determined by lithology and structure. The experiments showed that ground water sapping was important in forming the scalloped escarpments observed along the escarpments north of Kharga. We are also incorporating explicit chemical dissolution of carbonate rocks as another system component, since limestones are wide-spread in Kharga region [8] and have been hypothesized for Mars.

The Kharga escarpment is particularly germane to Mars in that the scalloped escarpments look similar (visually and fractally) to parts of the Valles Marineris escarpments. From our simulations, we believe that the scalloped appearance of the Kharga escarpments is caused by dissolution that occurs preferentially along fractures where there are high discharge rates. These high flow zones lead to preferential collapse of escarpment rocks and scalloped topography. We are currently pursuing extrapolation of ground water flow to martian conditions, to simulate sapping in silicate and carbonate rocks, and the scalloped escarpment landform of Mars, and to test the two hypotheses about martian surface conditions.

References: [1] Chase, C.D., 1992, *Geomorph.*, 5, 39-57. [2] Koltermann, C.E. and Gorelick, S.M., 1992, *Science*, 256, 1775-1782. [3] Howard, A.D., 1988, *NASA Spec. Pub.* 491, 71-83. [4] Turcotte, D.L., and Schubert, G., 1982, *Geodynamics,* 121-122. [5] Gilchrist, A.R. and Summerfield, M.A., 1990, *Nature*, 346, 739-742. [6] Molnar, P. and England, P., 1990, *Nature*, 346, 29-34. [7] Arvidson, R.E., et al., accepted by *J. G. R.* [8] Said, R., 1962, *Geol. of Egypt,* 71-76.