SIMULATING THE FORMATION OF LARGE ALLUVIAL FANS ON MARS. A.M. Morgan[1,2], R.A. Beyer[2], A.D. Howard[3] J.M. Moore[2], [1]Department of Earth and Planetary Sciences, University of California, Santa Cruz (ammorgan@ucsc.edu), [2]NASA Ames Research Center, MS-245-3, Moffett Field, CA 94035 (jeff.moore@nasa.gov, ross.a.beyer@nasa.gov), [3]Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903 (ah6p@virginia.edu).

Introduction: Numerous alluvial fans have been identified within large craters in the southern Martian highlands [1]. Many fluvial landforms have been identified on Mars, but alluvial fans are one of the few depositional ones, making them a unique target of interest in the ongoing exploration of the Martian surface. We use a landform evolution model [2] to simulate the growth of these fans in order to answer several key questions about their formation.

Approach: With our work we aim to answer several questions: (1) Why is the erosion of the deep crater-wall alcoves that source the alluvial fans restricted to one or a few locations around the crater circumference? (2) What were the characteristics of water discharges (flow magnitude and duration) and sediment supply (quantity and grain size range) during fan formation? (3) What are the implications of the fans with regard to the responsible climatic environment (e.g. amounts and frequency of precipitation as rain or snow)?

The model used is a modification to the Mars Landform Simulation Model (MLSM), which simulates weathering, mass wasting, and fluvial incision of the crater rim [2], in addition to larger-scale macro processes such as impact cratering. Added to this is a new set of routines that focus on alluvial fan deposition. It combines discharge and sediment transport with channel avulsion and abandonment. This allows the model to simulate both the micro and macro scale processes responsible for fan formation. We will simulate both fan development under a scenario of uniform precipitation over the crater walls and floor and an orographic pattern of greater precipitation on upper crater walls.

Eolian erosion of the Saheki Crater fans (Fig. 1) has revealed distributaries etched into positive relief, suggesting that deposition involved both in-channel aggradation of coarser bedload plus overbank sedimentation of wind-erodible suspended sediment. The model incorporates both processes. The model will allow for basic stratigraphy to be recorded as the fan is simulated.

Output from the model is being statistically compared with Digital Elevation Models (DEM) of the region using measures such as channel width, relative proportions of channel and overbank sediments, frequency of branching and recombination, and distributary lengths. Because the model records subsurface stratigraphy, we can conceptually subject the simulated fan to eolian stripping (assuming channel deposits are less erodible than overbank sediment) as has occurred with the Saheki Crater fans (Fig 1) to permit statistical comparison with the natural fan surface. In addition to current DEMs made from MOLA data, we have produced high resolution DEMs derived from HiRISE stereo pairs. Model output will also be compared with appropriate terrestrial examples (e.g. select alluvial fans in the Atacama Desert)

Initial Assumptions: Initial conditions for our simulations will be an 80-km diameter, geometrically simulated, fresh impact crater [2]. This is the prevalent size for craters supporting large alluvial fans [1].

Over the whole simulation a number of distributaries can be active, depending upon assumed model parameters and probabilistic creation and abandonment of distributaries. Factors such as flow rate are scaled to Martian gravity. Discharges of individual distributary channels are calculated based on the channel slope and a number of dimensionless parameters, such as the Shields stress [3]. New channels are created (avulsed) when a new route is determined to be more energetically favorable than the current one. Distributaries are abandoned when flow volumes drop below a specified fraction of the total discharge. Overbank sedimentation rate is parameterized as an inverse function of both distance from the nearest channel and of the fan surface height relative to the channel bed [4]. Overbank deposition rate is also positively related to distributary discharge and sediment concentration.

For simplicity, the grain size distribution is approximated as a combination of bedload (course sand or gravel) and suspended load (very fine sand and silt). Channels cease to exist if their discharge falls below a pre-determined critical flow value. Runoff is not allowed to pool (it is assumed to evaporate or infiltrate).

Conclusions: The model successfully creates fans such as illustrated in Figure 2. Depending upon model parameters assumed we can create fans ranging with varying numbers of both simultaneously-active distributaries and ratios of channel versus overbank sedimentation. The simulated fan features similar distributary patterns to fans seen on Mars (compare

Fig.1 and Fig. 2), including distributaries of different age and elevation that cross paths. The range of model assumptions that result in fans statistically similar to the Martian counterparts (based on our DEMs) will constrain the possible range of sediment properties and environmental conditions responsible for the Martian fans.

We are currently finalizing the stratigraphy component of the model and development of the initial relief on to which the simulation will operate. Once these tasks are completed we will compare our results to the actual Martian landscape and infer the prevalent local climatic conditions when the fans were formed.

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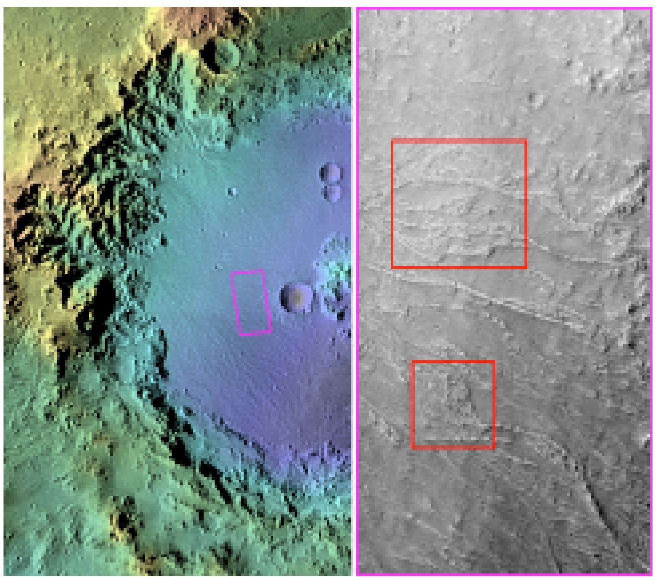

Fig. 1. Saheki crater overview. Crater diameter 84 km. THEMIS daytime IR image mosaic with MOLA-based elevation color cueing (left). Large fans are limited to the west side of the crater and are sourced from deeply eroded alcoves. The pink box is enlarged at right, showing manifestations of alluvial activity.

The ridges seen in the upper box are the differentially eroded remnants of channels formed through multiple avulsions. Aeolian stripping of fine, sediment has created the inverted distributary relief. This implies a bipodal distribution of bedload and suspended load sediment, which is simulated in the model. The lower box (width is approximately 1km) shows a scroll bar.

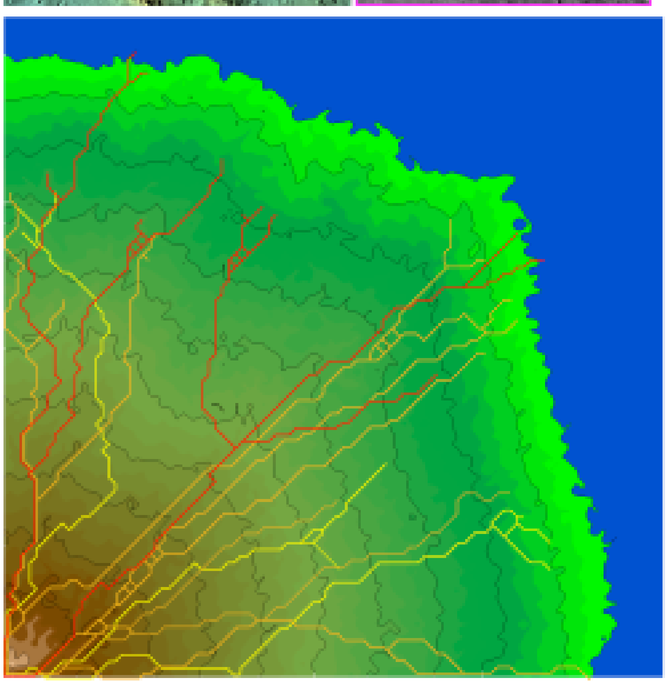

Fig. 2. Example of a fan that was constructed from the model. Blue is the elevation of the fan base. Simulation domain is 10km across. The distributary channel network at the end of the simulation is in red. Channel networks earlier in the simulation are in orange and yellow (oldest) and show how the system avulses and shifts over time. The dendritic and anastomosing pattern is similar to the features seen on the Saheki crater fans.

Various parameters can be adjusted to vary both the number of simultaneously active channels and the ratios of bedload versus overbank deposition. Comparing the ranges of these assumptions that match features on existing fans constrains the conditions for formation.