PROCESS-RESPONSE SEDIMENTARY MODELING OF ANCIENT MARTIAN DELTAS 1: INTRODUCTION AND CASE STUDIES. G. Di Achille[1], M. R. T. Hoke[2], A. P. Rossi[3], B. M. Hynek[2,4], F. Esposito[1], E. W. H. Hutton[5], A. J. Kettner[5], [1]Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Capodimonte, Napoli, Italy, [2]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, USA, [3]Jacobs University Bremen, Germany, [4]Department of Geological Sciences, University of Colorado, Boulder, USA, [5]Community Surface Dynamics Modeling System, Institute of Arctic and Alpine Research, University of Colorado, Boulder, USA.

Introduction: To date, little study has been dedicated to quantitative analysis of sedimentary processes and to a processes-based understanding of the stratigraphy, morphology, and overall paleohydrologic/climatic significance of the martian deltaic deposits. Therefore, despite their significant paleoenvironmental implications, martian deltas can not be uniquely used to assess whether they formed during extended epochs of clement climatic conditions [e.g. 1-3] or during limited and episodic climatic optima produced by regional factors [4-7]. We are carrying out a comprehensive study of the hydrology and sedimentology of martian deltas by using modified versions of state of the art terrestrial models whose concepts have been successfully tested in several different terrestrial settings [8,9].

Model and simulation approach: We use a martian-adapted version of the model *Sedlfux 2.0* [8,9] to reproduce synthetic (forward) simulations of martian deltaic features. The model was scaled for the reduced gravity and adjusted for terms like tide, the Coriolis effect, and fluid viscosity. *Sedflux 2.0* is an advanced process-response model capable of generating two- and three-dimensional stratigraphy during the delivery of multigrain-sized sediments into a body of standing water (Fig. 1 and Fig. 2). Input files for the simulations are: the bathymetry of the receiving basin and the water and sediments discharges at the mouth of the river flowing into it. Among all the processes represented by the model there are: river plume, bedload transport, sediment slope failure, turbidity currents, debris flows, subsidence, compaction, water base level changes, sediment remobilization due to waves and currents, river avulsion, and subaerial erosion and deposition by the river on the delta plain. Output files include a three dimensional grid of sediment property data for each grid cell of sediment within the simulation and the possibility to set a series of user-specified locations where measurement of several properties (e.g. bathymetric slope, water depth, mean grain size, etc.) can be collected at regular intervals. The key of this approach is the dynamical modeling of deltas based upon processes-response simulations. This allows to move test geological models forwards and backwards through time while changing hydrologic, sedimentary, and bathymetric conditions and check the results against the observed morphology and stratigraphy of the known database of martian deltas. Particularly, we use a two-fold simulation strategy:

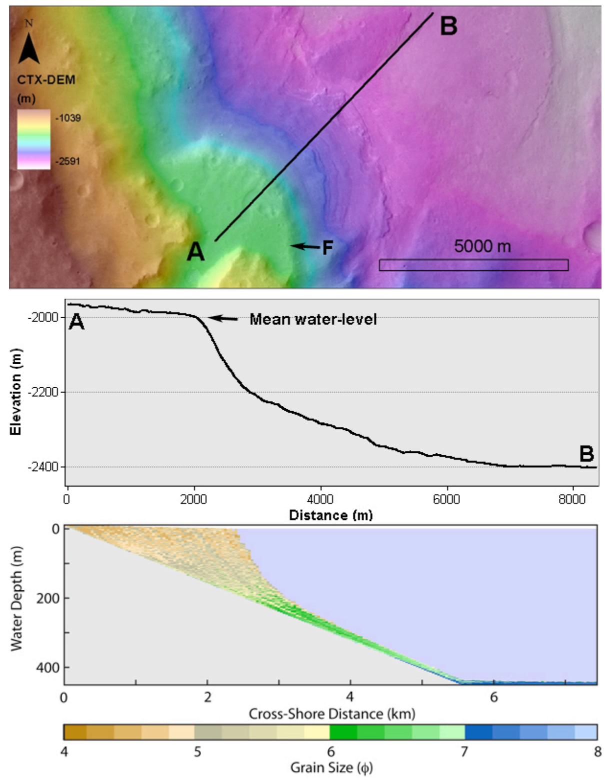

Figure 1. CTX-derived color-coded topography draped on CTX imagery showing the Subur fan-delta and the location of AB profile (top; F marks the delta front, a proxy for the mean water level). CTX-stereo AB profile from the Subur Vallis's mouth to the distal part of the fan-delta (middle). 2D Sedflu*x* cross section distribution of grain sizes (in Wentworth scale) across the simulated Subur delta (bottom).

(a) Parametrization of boundary conditions. We implemented several runs with (i) diverse discharges (both water and sediment load and grain-sizes) variable over time [10], (ii) diverse bathymetric settings of the receiving basin (steep vs. smooth basin gradient), (iii) different time steps and resolutions. This parametric study focuses on the analysis of grain-size distribution

within the deposits (both in 2D and 3D), resultant stratigraphy, and overall morphologic (e.g., shape and depositional patterns) and morphometric (e.g., volume and thickness) characteristics of the output sedimentary bodies (Fig. 1 and 2). Main aims of this analysis are: understanding the relationships between water level changes and delta morphology/stratigraphy and the effects of boundary conditions (mainly water and sediment inputs) on the formation timescales of martian deltas [10].

(b) Application to specific case studies. We implemented forward simulations to reproduce the observational evidence of several known martian deltas. Using high-resolution stereo-derived topography (Fig.1 and Fig. 2), such as HRSC (50-75 m/pixel) and especially CTX (~10 m/pixel) and HiRISE (~1 m/pixel), we inferred the majority of the input parameters like the bathymetry and the morphometric properties of the sedimentary bodies (i.e. area, height and especially the volume and thickness of the sediments within the deltas). Likewise, average hydrologic and sedimentologic inputs were inferred by using the morphometric characteristics of the distributary channels (i.e. width, depth, and slope) as determined from imagery and topographic data [10, 11]. Grain sizes and their relative proportions were derived from typical terrestrial ranges and tentatively constrained by THEMIS-derived thermal inertia, measurements from landed missions, and from sub-meter scale HiRISE images which provide the direct observation of the coarsest grain sizes within the sedimentary deposits. The sediment discharges were calculated using terrestrial sediment transport predictors modified for application to Martian flows [11]. Model runs were finished when the sediment volume transported and deposited through the simulation would match that of the actual deposits.

Preliminary results: The parametric study suggests that the overall morphology of the modeled deltas is mainly affected by a combination of the following factors: bathymetry, rate of sea-level change, and especially the water/sediment discharges and their temporal distribution. Multilobate (river-like) deposits preferentially form in case of smooth bathymetry and at the mouth of channels with non-uniform supplies opening into basins with relatively stable water base level. While a combination of high-frequency river avulsion and stable deep water level seems to be required to form Gilbert-type deltas, regardless of the other input parameters. High resolution and long (10^3 years) model runs are still underway, however, as would be expected, preliminary results suggest that the delta formation timescale decreases with increasing sediment discharge and/or concentration [10]. Finally, hypopycnal processes seem to be very efficient in transporting fine fractions throughout the basin beyond the main delta deposits. Therefore, formation timescales assuming that all the input sediments are deposited within the delta might be underestimated [10].

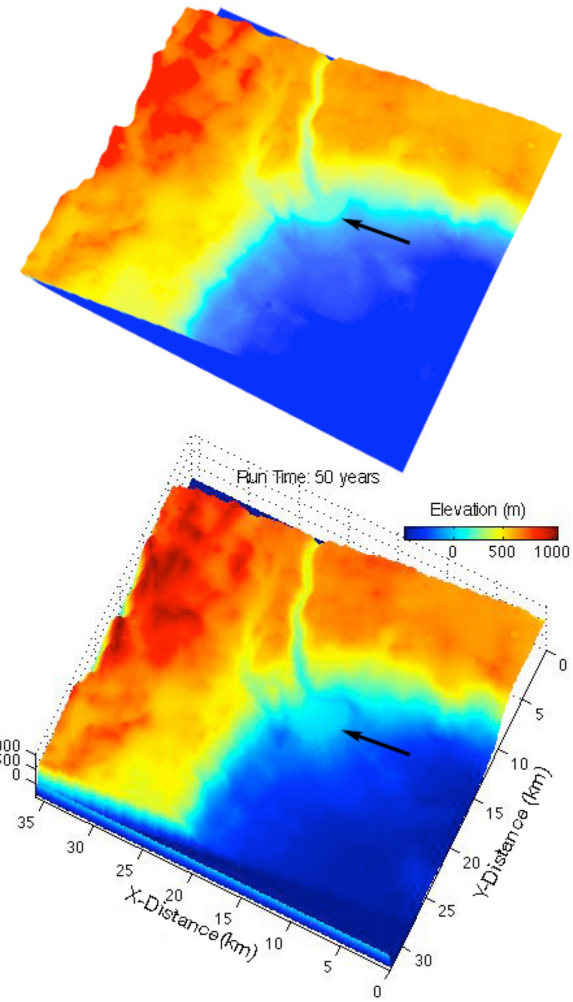

Figure 2. 3D view of the actual Subur delta (arrow) from CTX DEM (top). Sedflux 3D plot of the same delta (arrow) simulated over a 50 years timescale after editing the DEM to remove the actual delta (bottom).

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