DISTRIBUTION AND MORPHOLOGY OF VALLEY NETWORKS ON THE FLANKS OF ALBA MONS, MARS. Stephen P. Scheidt, David A. Crown, and Daniel C. Berman, Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, Arizona 85719 (sscheidt@psi.edu).

Introduction: Alba Mons, the northernmost Tharsis volcano, shows evidence for extensive fluvial dissection on its western and northern flanks. This research employs hydrological modeling and morphometric analyses to assess fluvial morphology within broader investigations producing 1:1M-scale geologic maps of the summit and western flank regions [1]. This study utilizes imaging and topographic datasets to both validate and extend traditional photogeological mapping of Alba Mons' fluvial systems. In addition to understanding aspects of Mars' climate history, our objectives are to qualitatively and, within the limits of available topographic data, quantitatively characterize the nature of fluvial activity, the interactions and temporal sequence(s) of valley network formation and other geologic processes, and the types of geologic units in which dissection occurred.

Background: Alba Mons is a large, low-relief volcano [e.g., 2-6]. The summit caldera complex, extensive lava flow fields, and prominent sets of graben have been described from Viking Orbiter data [7-16]. Various volcanic morphologies are present, including lava tubes, channels, and long tabular lobes [7-8, 15-18]. Valley networks have been mapped on the flanks of Alba Mons [9, 19-20] as well as on other volcanoes and terrains of Mars [e.g., 21-25]. Most Martian fluvial systems have been dated to the Noachian-Hesperian boundary, but the densest populations of valleys on Alba Mons were considered to be Amazonian [24]. Parameterization of land surface topography (e.g., channel profiles, density, length, width, slope and curvature) has proven to aid the interpretation of channels at Alba Mons [19], Hadriacus Mons [25] and in lower latitudes [21-22]. Hydrological modeling was used to map valley networks within Terra Tyrrhena [26].

Data Sets and Methodology: THEMIS infrared (IR) and CTX datasets were utilized for photogeological mapping of both volcanic [18] and fluvial linear features. Hydrological modeling methods [26] and land surface morphometric parameters (i.e., slope and curvature) were determined from gridded MOLA topography (128 pixels per degree, ~463 m per pixel) [27]. Valley networks and drainage basins were modeled using the Spatial Analyst hydrological modeling tools available in ArcGIS 10.4.1.

Morphological Mapping Results: Photogeological interpretations produced a preliminary map showing the distribution of valley networks, which were differentiated from volcanic channels and chains of lava tube collapse pits [17,18,28,29]. Mass wasting and mantling of the surface commonly obscures the signatures of fluvial features in image data. In general, mapped valley segments exhibit variable morphologies (e.g., width, depth of incision, and sinuosity). There are two primary groups: a) dense dendritic valley networks that are concentrated on the northern flank and on the highest regional slopes (Fig. 1) and b) on the northwestern flank, networks have straighter, longer trunks with short lower order tributaries. The westernmost drainage systems can extend for over 300 km and appear to be controlled by the distribution of volcanic ridges (interpreted to be lava tubes [18]). Many of the mapped valleys are 1^{st} and 2^{nd} order tributaries [30] that do not have clear connections in image data; these were grouped based on their apparent alignment and color-coded to show inferred network relationships (Fig. 2). We are using hydrological modeling from MOLA topography to refine and improve these mapping results, which will further help to infer tributary and higher order trunk connections.

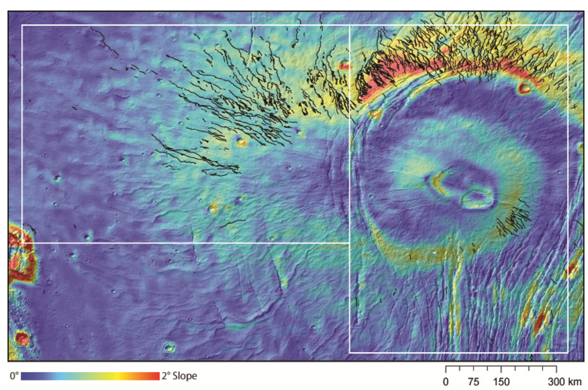

Figure 1. Valley networks on the flanks of Alba Mons. The basemap is slope over 25 km baselines calculated from a gridded MOLA DTM. White outlines show western flank and summit map areas.

Hydrological Modeling Results: Preliminary results were obtained from the following sequence of operations using MOLA topography as input for modeling valley networks: Fill (all sinks were filled, no depth limit), Flow Direction and Accumulation, Stream Order [30], and conversion of raster to features. Modeling yielded an initial 38 basins across the flanks of Alba Mons that contain up to 5^{th} order stream trunks. Only 11 basins contain mapped fluvial channels. A basin on the northern flank of Alba Mons (Fig. 2, label No. 1) has a long axis, downslope length of 716 km and comprises an area of 1.2×10^5 km^2. A basin on the western flank (Fig. 2, label No. 2) is narrower with a length of 1,043 km and an area of 1.3×10^5 km^2. Both of these valley networks have drainage densities ≈ 0.05 km^{-1}. Our preliminary results suggest that undissected portions of Alba Mons may have also been affected by fluvial processes, with the lack of mapped valleys due to burial and degradation or lack of dissection due to infiltration.

Discussion: Modeling parameters, such as spatial resolution of the topography, scale, and sink fill depth, affect the model results [see 26]. For example, the basins shown here are all open systems due to our initial use of an unconstrained fill limit. Comparisons of mapped valley networks with modeled drainage basins and networks provide important insights into both modeling approaches and fluvial processes at Alba Mons. In many areas, mapped and modeled valley networks are in very close agreement, providing confidence in mapping results. This also suggests that these valleys formed in the current topographic surface and allows modeled drainage divides to be used for basin analyses. In other areas, mapped features cross modeled drainage divides. Large regional graben significantly affect modeling results, but our observations show that graben clearly crosscut (post-date) fluvial features [1]. Disagreements between mapped and modeled valley networks can be used to identify locations where the topography may have been modified by tectonism or volcanism after fluvial dissection. Likewise, areas of disagreement also provide opportunities to improve our hydrological modeling by refining input parameters (i.e., sink fill depth) or utilizing higher spatial resolution topography to refine 1st and 2nd order networks (i.e., HiRISE or CTX DTMs). Future modeling will expand the study area beyond Alba's flanks to fully characterize basins as well as employ higher resolution topography.

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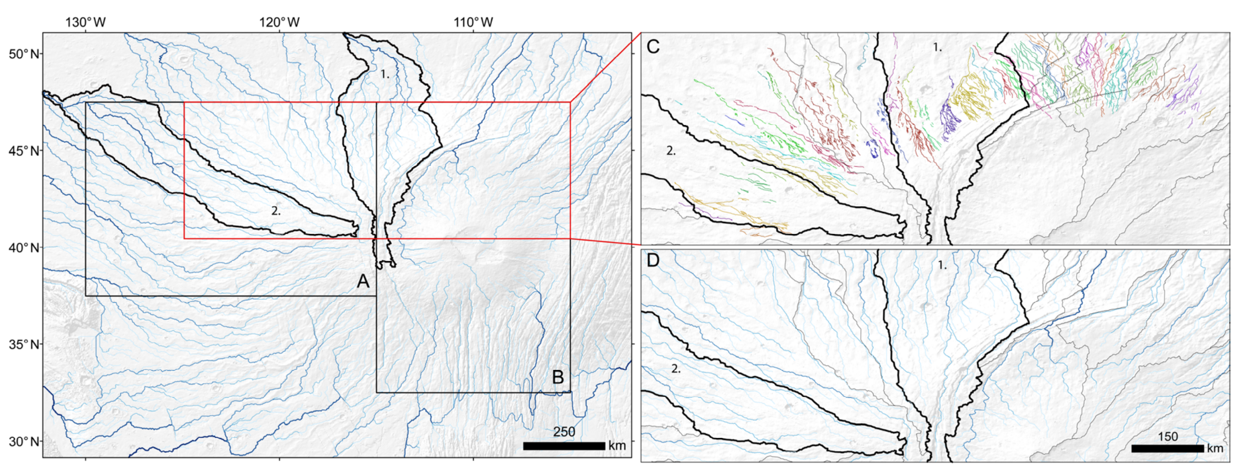

Figure 2. Left panel: Valley networks (blue lines) estimated from hydrological modeling. A. Western flank map area. B. Summit region map area. Red inset and right panel: C. Valley networks mapped from THEMIS and CTX, grouped into likely sub-basins by color. D Modeled valley networks (blue lines). Example basins (bold black outline) located on the northern (Label No. 1) and western flanks (Label No. 2) of Alba Mons.