HIGH-RESOLUTION GEOLOGIC MAPPING OF TERRACED FANS IN XANTHE TERRA, MARS. Jeannette M. Wolak, Natalie N. Robbins, Allison M. Bohanon, and Hannah E Blaylock, Department of Earth Sciences, Tennessee Tech University, 1 William L Jones Drive, Cookeville, TN, 38505; jwolak@tntech.edu.

Introduction: The Xanthe Terra region of Mars hosts a variety of fan-shaped features, including terraced fans, a subset characterized by their small aerial footprint (< 10km diameter) and concentric, alternating zones of steep and shallow slopes. To date, approximately 84 such features have been identified on the global martian surface [1], and plausible interpretations for formation range from fluid-poor models, i.e. alluvial fan deposition [2], to fluid-rich models, i.e. deltaic deposition or sustained overland flow [3, 4]. Most terraced fans occur in late Noachian to early Hesperian geologic units [1, 5]; however, recent work demonstrates that the fans themselves may be significantly younger than surrounding terrains [6].

The purpose of this project is to create a series of high-resolution geologic and geomorphic maps of terraced fans in the Xanthe Terra region and use these maps to test competing formative models of deposition. Prior mapping efforts provide valuable context [4, 6, 7]; however, most published geologic maps of terraced fans are low resolution and do not provide information about the abundance or distribution of small-scale features such as boulders, incised valleys, distributary channels, narrow levees or barforms. Many of these observations can be linked to sedimentological process; thus, high-resolution mapping provides a valuable framework for interpretation.

Study Locations: A recent global survey of approximately 1,300 fan-shaped features on Mars categorized geometries as either semi-conical alluvial fans, terraced or stepped fans, or low gradient deltas [1]. Approximately 6% of the surveyed features were identified as terraced or stepped fans, including many fans previously documented in the Xanthe Terra region [3, 4, 6]. Most fans in Xanthe Terra are associated with feeder channels that cross Noachian to Hesperian highlands units, incise steep crater walls, and result in classic point-source deposition adjacent to the crater rim. Examples of terracing can be seen in fans located at the debouchements of Tyras Vallis (8.45ºN, 310.27ºE) and Subur Vallis (11.73ºN, 307.07ºE) as well as in Camichel Crater (2.69ºN, 308.33ºE) and Dukhan Crater (7.59ºN, 321.02ºE). The latter two locations have adequate Context Camera coverage and high-resolution stereo pair imagery from the High Resolution Science Experiment (HiRISE) to support detailed mapping efforts, shown here in Figure 1.

Geologic Mapping: Given that individual terraces may range from several meters wide to less than a meter wide, high-resolution mapping parameters were designed to capture as much detail as possible and facilitate sedimentological interpretations. The scale of mapping is 1:18k, comparable to recent mapping of structurally-complex regions in Candor Chasma [8]. Line work follows standardized mapping procedures outlined in the 2018 Planetary Geologic Mapping Protocol [9], and mapping is conducted at a scale of 1:4k, four times the proposed publication scale. Vertex spacing for line work is 4m, and geologic units are defined based on visual characteristics including tone, terrain roughness, abundance of boulders, and stratigraphic position. Mapping of multiple terraced fans shows a general stratigraphy that appears to be common to fan systems and includes, from oldest to youngest: (1) crater floor and wall terrains; (2) distal (lower) fan terraces; (3) proximal (upper) fan terraces; (4) feeder channel infill deposits; and (5) aeolian deposits.

Camichel Crater Fan Mapping: The fan located in Camichel Crater measures approximately 6.5km across the broadest terraces. The most distal deposits associated with fan deposition are 11km from the fan apex, the point at which flow parameters changed from confined within the feeder channel to unconfined adjacent to the rim of Camichel Crater. General measurements of fan thickness using Mars Orbital Later Altimeter (MOLA) data show that the thickest parts of the proximal fan are 340-380m thick; however, this estimate assumes that terraces are subparallel to the underlying crater floor, and the crater floor has not subsided due to loading of fan material.

Two crater floor units are identified in Camichel Crater, and cross-cutting relationships suggest that these terrains are significantly older than fan units, a conclusion that is consistent with crater counts documented in Hauber et al. [6]. Six terraced fan units are defined based on subtle changes in texture and tone of the base orthoimage. These record changes in depositional process from older, distal terraces to younger, proximal deposits. Although aeolian features are visible on the surface of the Camichel Crater fan, they do not generally obscure geologic contacts, and thus they are not mapped as a different unit.

Dukhan Crater Fan Mapping: The Dukhan Crater fan is located approximately 800km east-northeast of Camichel Crater, on the eastern edge of the Xanthe highlands unit. The dimensions of the fan are similar to the Camichel Crater fan: 8.5km in diameter and 10.5km from fan apex to the most distal fan deposits. Fan thickness estimated from global MOLA topographic data is 530-550m; however, the rim of the Dukhan Crater dips to the northwest, parallel to the fan axis, and thus, fan thickness may be overestimated.

Although similar stratigraphic trends are observed on both terraced fans, geologic contacts on the Dukhan Crater fan are masked by thick, widespread dune deposits. Dune fields and sand sheets are therefore mapped as a separate unit (Figure 1). With respect to older terrains, two crater floor units are identified as well as a highlands unit that includes the crater rim and walls of an incised feeder channel [10]. Six units are defined that characterize fan deposition, and these are best exposed on broad terraces between younger dune deposits (Figure 1).

Future Work: Next steps include detailed documentation of map units and development of a correlation of map units for each fan. Additional geomorphic maps have been generated that show the abundance and distribution of dunes and boulders, which can be used to determine depositional process and the likelihood of fluid-rich versus fluid-poor development.

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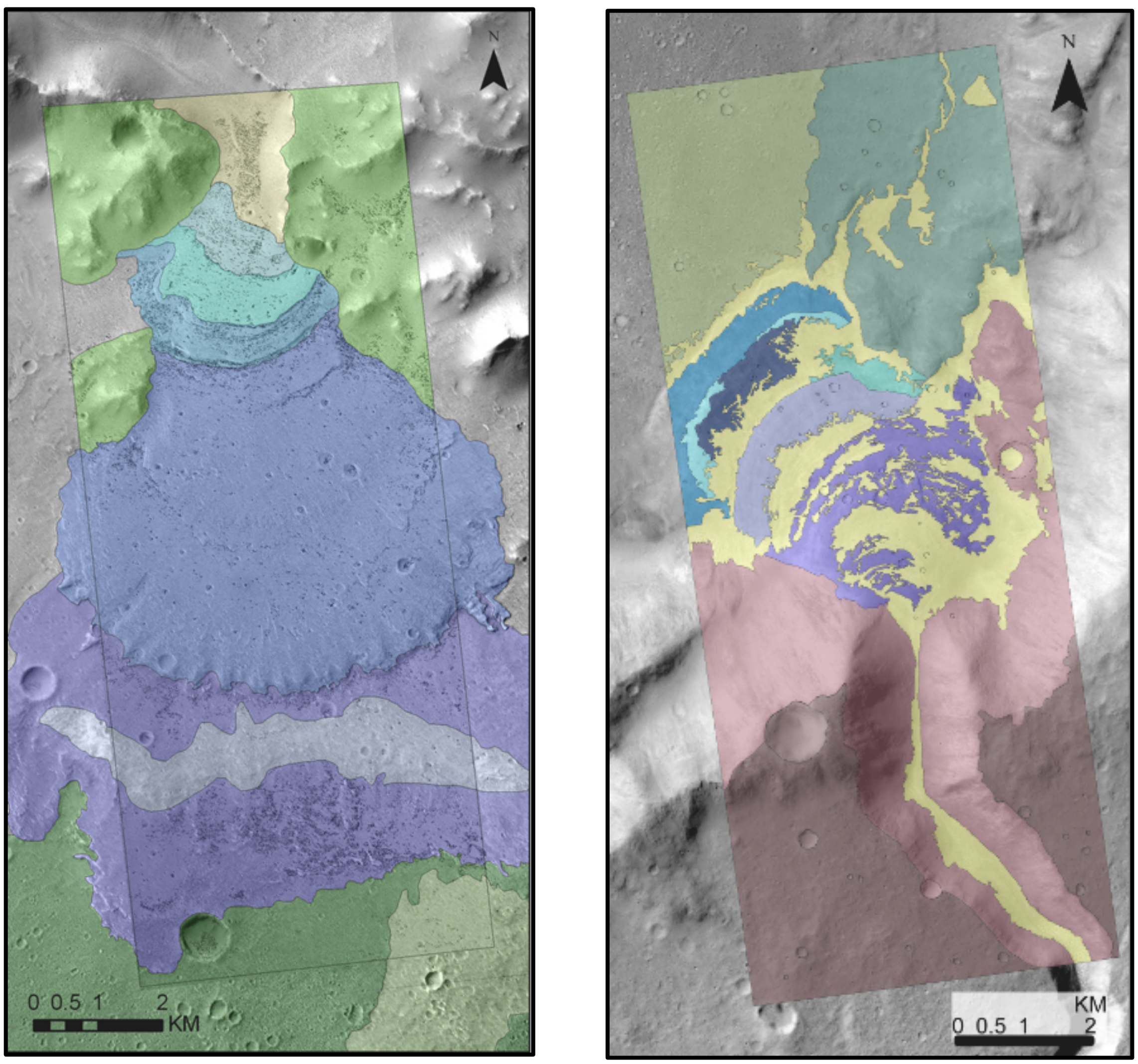

Figure 1. High-resolution 1:18k geologic mapping of terraced fans located in Xanthe Terra: the Camichel Crater fan (left image, 2.69ºN, 308.33ºE) and Dukhan Crater fan (right image, 7.59ºN, 321.02ºE). Both features show a similar general stratigraphy of older crater floor units (greens) and terraced fan deposits (purples and blues); however, contacts on the Dukhan Crater fan are masked by extensive aeolian deposition (yellow).