HIGH-RESOLUTION GEOLOGIC MAPPING OF A TERRACED FAN IN GARU CRATER, AEOLIS MENSAE, MARS.

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Introduction: This presentation is the culmination of three years of work mapping terraced fans in the Xanthe Terra and Aeolis Mensae regions of Mars. To date, we have created high-resolution maps of fan-shaped features in Camichel and Dukhan Craters and conducted preliminary mapping at the terminus of Subur Vallis [1, 2]. Our final target for comparison, a stepped or terraced fan in Garu Crater, is highlighted for a forthcoming USGS Scientific Investigation Map (SIM). Garu Crater is located less than 250 km from the landing site of the Mars Science Laboratory rover (Figure 1), and recent workers have focused on the feasibility of regional connected groundwater systems in the area during the Early to Late Hesperian [3, 4].

Methods: We based geologic mapping of the Garu Crater fan on a 0.25 m/pixel HiRISE orthoimage of product PSP_009729_1735. The orthoimage and a corresponding digital terrain model (DTM) were generated using Bae Systems SOCET SET software, following procedures outlined in the 2015 USGS Stereo Processing Workflow [5]. To improve bundle adjustment, the SufaceFitPcAlign tool from Ames Stereo Pipeline was used, and approximately eight hours of manual editing amended areas with low frequency jitter errors. The final high-resolution products include two orthoimages, two anaglyphs, and a 1 m/pixel DTM over the Garu Fan.

Supplemental data for mapping included CTX images B01_009874_1735_XI_06S218W and F037130_1736_ XN_06218W. These are particularly useful because HiRISE coverage of the Garu Crater fan does not extend into the feeder canyon, nor does it cover the most distal deposits on the crater floor (Figure 1). Thus, it was useful to extend mapping of some units beyond the target HiRISE area, especially to confirm the extent of crater wall and margin deposits. Regional mapping was conducted at lower resolution and was only used to confirm the contacts of units that connect beyond the primary base map area.

Given that terraces on the Garu Fan range from less than 1 m wide to several meters wide, high-resolution mapping techniques were designed to capture as much detail as possible and facilitate sedimentological interpretations. The digital mapping scale was 1:4k. Vertex spacing was 4 m, and the finished map product is 1:18k. This is comparable to other recent high-resolution maps, including those generated to investigate structural complexity in the Candor Sulci, Ceti Mensa, Candor Chasma and Candor Colles regions of Mars [6, 7]. Line work, geologic units, symbology, and nomenclature follow the guidelines for standardized maps presented in the 2018 Planetary Geologic mapping protocol [8].

Results: As shown in Figure 1, we identified a total of fourteen geologic units based on visual characteristics including tone, texture, terrain roughness, boulder distribution, and stratigraphic position. In general, the fourteen units can be organized into the following groups, from oldest to youngest: Garu Crater Units, Garu Fan Units, and Crater Units.

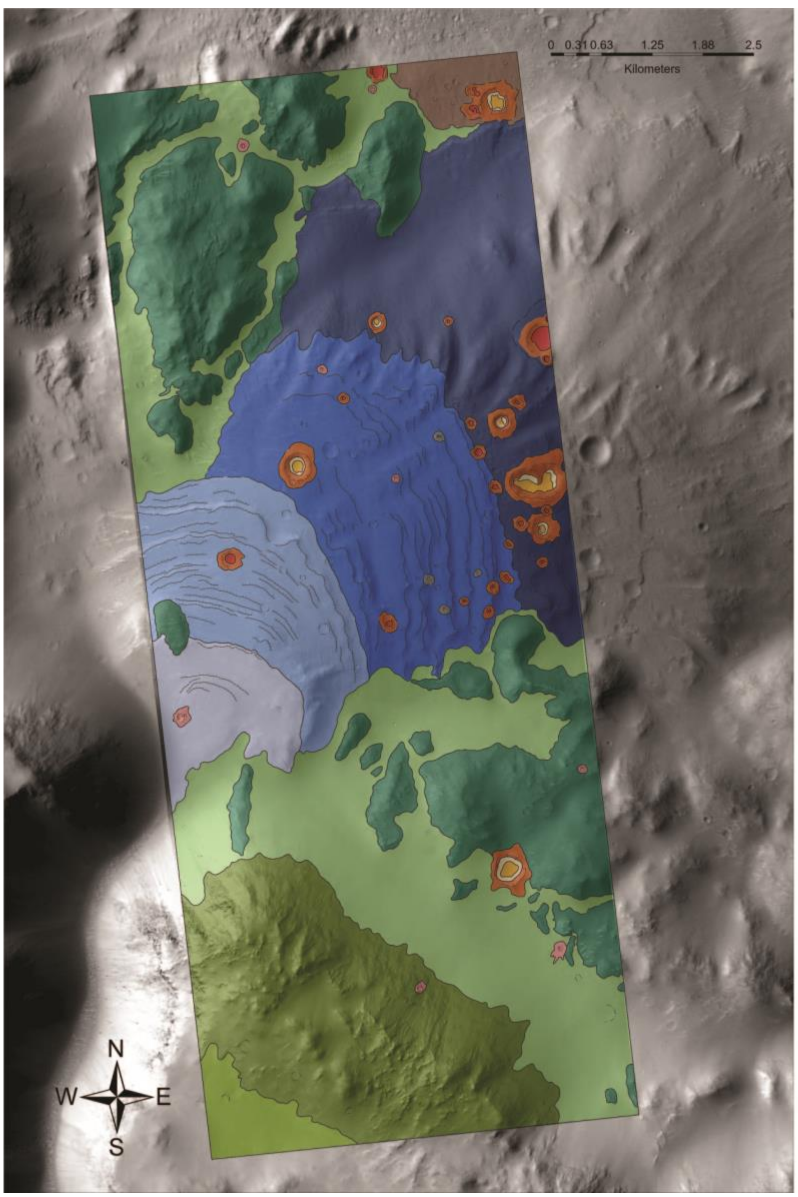
Garu Crater Units. The oldest stratigraphic units in the study area are a rugged, blocky unit outcropping along the rim of Garu Crater (GCr) and an adjacent unit of smooth, layered ejecta (GCe). The former is interpreted as strata that were deformed and upturned during the Garu impact event; the latter, a combination of ejecta excavated from the cavity during impact and remobilized sediment eroded from crater rim peaks after impact. Adjacent and onlapping these units, the Garu Crater wall block unit (GCwb) and smooth wall unit (GCsw) are characterized by rugged to hummocky blocks and smooth, light-toned sloped deposits, respectively. These units record post-impact deformation of the crater walls as blocks of the Garu Crater cavity slid inwards toward the center of the crater. Subsequent sedimentation via fluid seepage along the inner walls of the crater created smooth, sloping deposits between wall blocks. Finally, the Garu Crater floor unit (GCf) is a pitted, hummocky unit. We interpret this outcrop in the northeastern corner of the primary map area as impact-generated melts and fines deposited after the Garu Crater impact event and modified by volatile escape and erosion.

Garu Fan Units. The southwestern rim of Garu Crater is incised by a narrow feeder canyon that cross-cuts units GCr and GCe. A terraced fan sourced from the canyon downlaps onto the crater floor (GCf) and onlaps adjacent wall units GCwb and GCsw. The fan measures ~5 km at widest diameter and ~10 km from the proximal fan apex to the most distal deposits on the crater floor. Fan units are divided into four facies, each characterized by changes in terrace height, spacing, tone, texture, and depth of gully incision. The lowermost unit, GFd, shows discontinuous terrace scarps and deep gully incision. The northernmost extent of this unit is very smooth, lacks scarps and gullies and onlaps deposits of the Garu Crater wall and floor units (GCwb, GCsw, and GCf). Overlying the GFd unit, the GFc facies is characterized by discontinuous to continuous scarps, some with heights up to 22m.

Terraces on this unit measure 25-200 m wide, and gully incision is less pronounced than GFd. In both lower fan units, gullies appear to radiate from the fan apex and cross-cut terraces at a perpendicular angle. Facies GFb is characterized by well-preserved terraces measuring 25-300 m wide and ranging in height from 2-12m. Some terraces in GFb can be continuously traced radially around the fan. At the top of the fan-shaped feature, unit GFa shows weathered, discontinuous scarps and backfilling of the feeder channel system. Both units GFa and GFb onlap outcrops of wall blocks, which suggests that deposits on the upper portion of the fan are filling in pre-existing topography.

Crater Units. The youngest features observed in the study area are impact craters that post-date the Garu impact, development of the feeder channel, and sedimentation associated with the Garu fan system. Crater mapping includes the following size divisions: (1) craters smaller than 50 m are not mapped; (2) craters 50-75 m are mapped as a single undivided unit; (3) craters > 75 m are mapped as divided units. For the latter, wall and floor units may be broken out individually (Cw and Cf) or grouped if they are indistinguishable on the base map (Cwf). Crater rims and ejecta are also mapped as unit Cr.

References: [1] Wolak et al. (2019) *PGM Abstract 7009*. [2] Wolak (2018) *GSA Abstract 50*(3). [3] Putnam and Palucis (2020) *JGR*. [4] Rivera-Hernández and Palucis (2019) *GRL 46*(15). [5] USGS (2015), *HiRISE Stereo Processing Workflow*. [6] Okubo and Gaither (2017) *USGS SIM 3359*. [7] Okubo (2014) *USGS SIM 3309*. [8] Skinner et al. (2018) *USGS PGM Protocol*.



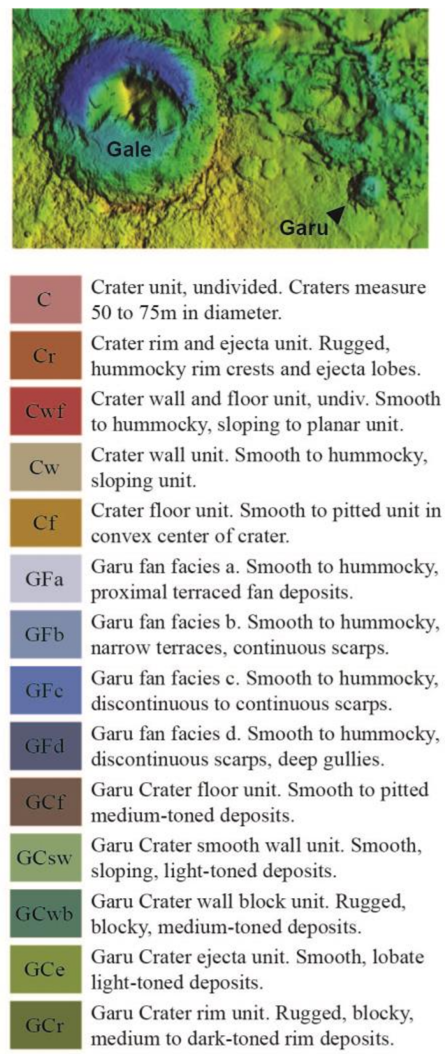


Figure 1. Location, units, and geologic map of a terraced fan in Garu Crater, Aeolis Mensae, Mars.