GEOLOGIC MAPPING IN SOUTHERN MARGARITIFER TERRA.

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Introduction: Margaritifer Terra records a complex geologic history [1-5], and the area from Holden crater through Ladon Valles, Ladon basin, and up to Morava Valles is no exception [*e.g.*, 6-13]. The 1:500,000 geologic map of MTM quadrangles –15027, –20027, –25027, and –25032 (Figs. 1 and 2 [14]) identifies a range of units that delineate the history of water-related activity and regional geologic context.

Mapping Results: Within the map area (Figs. 1 and 2), the degraded Ladon and Holden multi-ringed impact basins [15] are the oldest features with ring structures reduced to isolated mountains (Nm). The most widespread unit is the Noachian Terra unit (Nt), which includes basaltic bedrock [16], impact ejecta, weathered rocks [17], fluvially reworked sediments, airfall or eolian traction materials, and perhaps other rocks. Fluvial dissection is common, and layering is evident in places. Terra unit surfaces are reworked by impacts [18], typically rolling, and retain small craters poorly relative to smooth basin fills [19, 20].

Late Noachian-Early Hesperian channel materials of Uzboi, Ladon, and Morava Valles include exposed bedrock outcrops, eroded Terra unit (Nt), and alluvial veneers. The Channel 1 unit (HNch$_1$) represents initial dissection that was abandoned when the main channels were downcut (HNch$_2$).

The Early-to-mid Hesperian ejecta (Hc) of Holden (26.0°S, 325.8°E) and Ostrov (26.5°S, 332°E) craters postdate these units and resurfaced most of the southwestern part of the map area (Fig. 1). Megabreccia in Holden crater is exposed along the southern crater wall [11]. In the Holden impact basin, a superimposed thick fill unit (HNb$_2$) is interpreted as moderately to strongly indurated alluvial, volcanic, or eolian materials, where origin and composition may vary.

After Holden crater formed, Holden and Eberswalde (23°S, 327°E) craters accumulated phyllosilicate-bearing light-toned layered deposits (LTLDs) (Hh$_2$ and HNe) with broadly similar stratigraphy [11, 13, 21], suggesting a similar depositional environment. In both cases, beds are often <1 meter thick and can be traced laterally for hundreds of meters. The deposits are confined to low elevations and do not drape exterior surfaces, favoring low-energy alluvial or lacustrine deposits over airfall materials or volcanic ash.

The origin of phyllosilicates observed in LTLDs of Holden crater (Hh$_2$), Eberswalde crater (HNe), Ladon impact basin (H1), and other depressions has implications for habitability [11, 13], as it reflects prolonged weathering. Holden crater initially drained internally, so phyllosilicates were either eroded from sedimentary rocks exposed on the crater walls, or chemical weathering occurred in the crater [13].

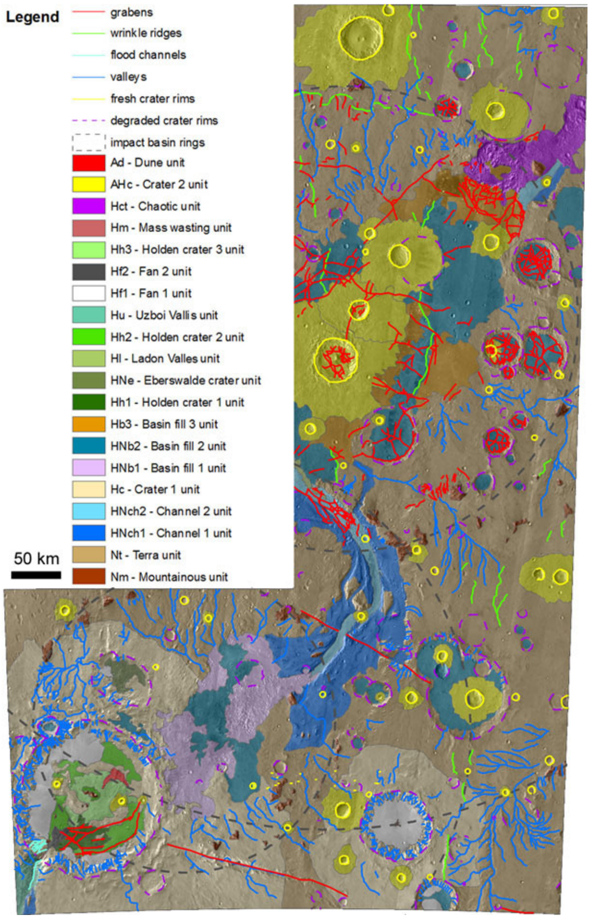

Figure 1. Geologic map and abbreviated legend for MTM quads –15027, –20027, –25027, and –25032 completed at 1:500,000 [14].

Holden and Ostrov craters include some of the most extensive alluvial fans on Mars (Hf$_1$). Large alluvial fans formed preferentially along the rims of deep, Late Noachian to Early Hesperian impact craters that were not substantially modified by Noachian erosion [22, 23]. Ostrov crater has unusually deep rim dissection, sourcing an alluvial bajada that spans the circumference of the crater. These fans ramp down to the central peak, and a paucity of evidence for deep ponding suggests that the groundwater table was typically below the crater floor, consistent with infrequent precipitation runoff in an arid paleoclimate around the Noachian-to-Hesperian transition. By contrast, Holden crater contains a fringing bajada along its higher western wall, but the lower eastern wall experienced very little erosion or deposition. The bajada has a relationship between contributing area and slope that is consistent with fluvial rather than debris-flow-dominated fans, and the inverted channels on fan surfaces show that inter-channel deposits were dominantly composed of sand and fines [22], so high-magnitude runoff may have been uncommon.

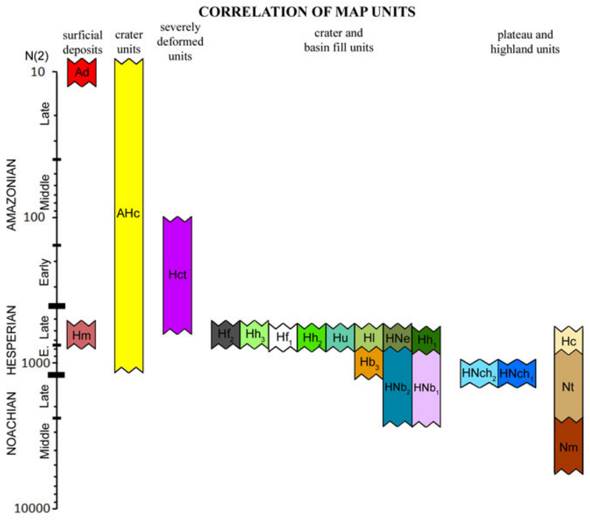

Figure 2. Correlation of map units for the completed geologic map shown in Figure 1 [14].

The putative delta in Eberswalde crater consists of alluvium sourced from a basin to the west, which had been resurfaced by Holden crater ejecta. The alluvium likely includes Holden crater ejecta, weathered Terra unit rocks, and materials from the Eberswalde rim, similar to those occurring in the Holden crater fans. Finally, Holden and Eberswalde craters record variable water levels. In Holden, LTLDs on the floor and > 200 m up the wall suggest a deep lake. In Eberswalde, lateral migration of channels suggests base-level stability over at least century timescales [14, 24].

The youngest layered deposits in Holden crater are the Fan 2 unit (Hf_2) and the Holden crater 3 unit (Hh_3). The Fan 2 unit is coarse-grained with visible boulders in HiRISE images, despite the low gradient of the fan, and it has a multi-lobed planform emanating from a breach where Uzboi Vallis enters the crater. These characteristics suggest origin during a large flood when a paleolake in Uzboi Vallis drained into the crater. The Holden crater 3 unit is interpreted as more distal, fine-grained deposits from the same event modified by more recent eolian activity.

Water-driven erosion and sedimentation may have extended well into the Hesperian, which was also characterized by resurfacing of certain basin floors by eolian or volcanic activity that was concentrated in and around Ladon basin. Amazonian activity was largely confined to a dune field (Ad) inside Holden crater.

Summary: The mapped units and events defined during the recently completed effort describe widespread Noachian to mid-Hesperian aqueous activity in southern Margaritifer Terra that shaped large channels, valley and alluvial systems, and even lakes. The preserved landscape holds important clues related to the early history of Mars and whether habitable conditions may have occurred. Nevertheless, the existing maps are only a part of the story related to understanding the cause, timing, and extent of aqueous degradation of the region and how it relates to a global hydrologic cycle.

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