GEOLOGY OF HOLDEN CRATER AND THE HOLDEN AND LADON MULTI-RING IMPACT BASINS, MARGARITIFER TERRA, MARS.

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Introduction: Geologic mapping at 1:500K scale of Mars quads 15s027, 20s027, 25s027, and 25s032 (Fig. 1) is in progress to constrain the geologic and geomorphic history of southwestern Margaritifer Terra. This work builds on earlier maps at 1:5M [1] and 1:15M scales [2], recent to concurrent 1:500K-scale mapping of adjacent areas to the east [3–5], and studies of drainage basin evolution along the Uzboi-Ladon-M (ULM; the third valley in the sequence has no formal name) Valles basin overflow system and nearby watersheds [6–9]. Two of the six landing sites under consideration for the Mars Science Laboratory rover are in this map area, targeting finely layered, phyllosilicate-rich strata and alluvial fans in Holden crater [10–12] (26°S, 34°W, 150 km diameter) or deposits southeast of a likely delta in Eberswalde crater [13–16] (24°S, 33°W, 50 km in diameter). Diverse processes including larger and smaller impacts, a wide range in fluvial activity, and local to regional structural influences have all affected the surface morphology.

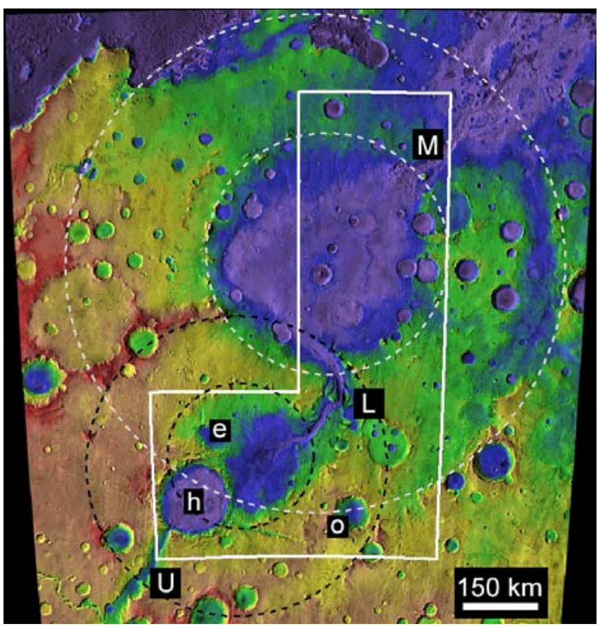

Fig. 1. Map area outline (white) with Ladon (gray) and Holden (black) basin rings dashed. Labels are Uzboi (U), Ladon (L), and a third unnamed valley (M); Holden (h), Eberswalde (e), and Ostrov (o) craters.

Large Impact Basins: The Early Noachian Ladon and Holden multi-ring impact basins (distinguished from the younger Holden crater), with inner/outer ring diameters of ~500/1000 and ~300/600 km, respectively (Fig. 1), are the oldest evident structures in the map area. Holden ring structures overprint those of Ladon [17], and the combination of the two structures oriented basin overflow floods and lesser fluvial activity over ~95% of the map area (Fig. 1). ULM segments follow the regional gradient to the NE and are radial to basin centers, except where the outer ring of Holden basin diverts Ladon Valles to the NW as it enters Ladon basin. Drainage from the southeastern margin of the study area was similarly confined within the outer Ladon basin ring (Fig. 1), wherein it joined lower Samara Valles and debouched to Margaritifer basin outside the NE corner of the area [7]. Eberswalde crater lies within the inner ring of Holden basin, which defines much of its watershed margin. Holden crater's location on the inner Holden basin ring created an asymmetry in the crater rim height, with a lower but less eroded eastern rim inside the older basin.

Intercrater Plains: Intercrater surfaces evolved during the Noachian Period with reduction of short-wavelength topographic relief, resurfacing, infilling and loss of impact craters as new ones formed, and partial infilling of the Ladon and Holden basins [7]. This terrain forms the cratered and subdued cratered units of [2] and the Noachis Terra unit of [18]. Eberswalde and other highly degraded craters formed and were modified during this time.

ULM Activity: A large supply of water to Holden basin via Uzboi Vallis led to overflow and incision of an outlet breach (Ladon Valles) [6]. The larger Ladon basin then filled and overflowed, forming unnamed valleys labeled M in Fig. 1. Multiple hanging channels in these outlets record large discharges that the initial topography could not confine. These flows coalesced with incision of the outlet breach, abandoning some higher channels [19]. The water volume needed to overflow Ladon basin was on the order of 10^4–10^5 km^3. Preservation of ULM valleys suggests that they postdate much of the intercrater plains development.

Holden Crater: The Holden crater impact destroyed and dammed the lower reach of Uzboi Vallis where it debouched to Holden basin. Holden crater is late Noachian in age, and some of its textured ejecta are preserved along with extensive chains of secondary craters to the north [1].

Holden crater stratigraphy. Megabreccia forms the base of the stratigraphic sequence in Holden crater and is overlain by >100 m of light-toned, layered deposits (LTLD) [12] (Fig. 2). These strata are poorly resistant to wind and rich in phyllosilicates, with bedding that is often <1 m thick and continuous for kilometers. These features suggest distal alluvial or lacustrine deposition [12]. Holden crater was initially an enclosed drainage basin with no external contributing valleys. The walls of Holden and Ostrov craters became deeply eroded, and alluvial fans of gravel and fines accumulated along the base of the interior walls [11]. These fans prograded over and now protect LTLD outcrops, which may be coeval. Alluvial fans are concentrated along the higher western wall of Holden crater but are well-developed throughout Ostrov. The alluvial deposit or delta in Eberswalde crater overlies Holden ejecta and is likely contemporary [14].

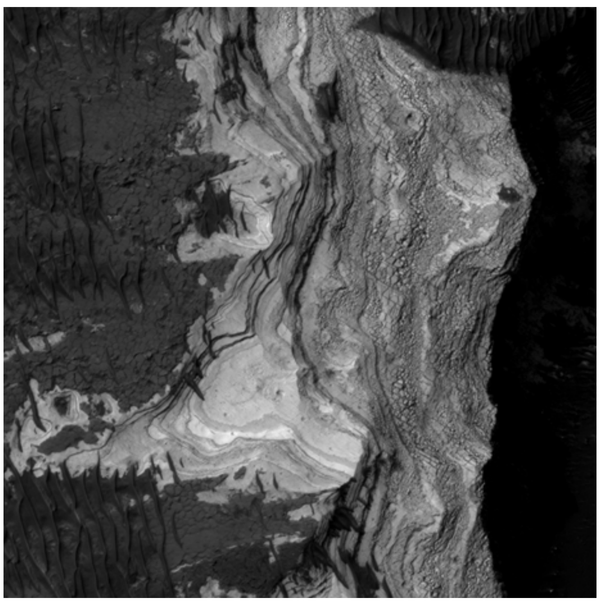

Fig. 2. Light-toned strata on the Holden crater floor, from the High Resolution Imaging Science Experiment.

Late Fluvial Activity: The Bond and Holden impacts created an enclosed basin in Uzboi Vallis, which drainage from the Nirgal Vallis tributary appears to have filled and overflowed. Full breaching of the SW Holden crater rim rapidly flooded the crater floor, incised channels, and deposited lobes of gravel and boulders over the LTLD. A small channel in lower Uzboi Vallis may represent the later stage of flow [12].

Structural Geology: Minor compressional faults striking N/S occur in several locations throughout the map area, whereas roughly concentric and radial normal faulting disrupted low-standing surfaces mostly in the northern half of the area. The latter modification is concentrated in deeper impact craters and basin floors within the inner Holden and Ladon basin rings, including the southern part of the Holden crater floor. Extensional faults typically do not extend into adjacent upland surfaces or intercrater plains, and they crosscut wrinkle ridges where the two faults intersect. Grabens cut the ejecta and floors of some fresh impact craters, whereas other craters superimpose the troughs, suggesting Hesperian or later faulting.

Chaotic or knobby terrains formed in Holden basin, upper Ladon Valles, and the upper reach of the valleys labeled M in Fig. 1 after basin overflows incised the outlet valleys [7]. The floor of Ladon basin is severely faulted near the margin of the chaotic terrain, which may be coeval with the grabens. In lower Ladon Valles, the upper reach of valleys labeled M in Fig. 1, and Holden crater, chaotic terrain or grabens are associated with uplifted areas in the floors. These structural features may be contemporary with outflow channel activity in Ares Vallis and elsewhere.

Recent Features: More recent modifications are largely aeolian and differentially affected basin floors. A dark dune field occurs in east-central Holden crater, and most fluvial deposits therein have etched surfaces. The floor of Ladon basin is also etched in places. A number of small impact craters have ejecta blankets that are distinct in infrared imaging, likely the most recent impacts in the map area.

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