Geologic Mapping to Constrain the Sources and Timing of Fluvial Activity in Western Ladon Basin, Mars

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Introduction

- We are mapping two quadrangles in Margaritifer Terra (–15032 and –20032) to define the evolution of the western Ladon basin region as it relates to fluvial/alluvial events occurring on surrounding surfaces.
- The western section of Ladon basin and its bounding basin ring structures to the west hold numerous clues to understanding the long history of drainage across the Margaritifer Terra region of Mars.
- As part of this mapping, we are also evaluating the morphology, mineralogy, and distribution of newly identified sedimentary deposits in small inter-ring basins in the highlands west of Ladon basin.
- We hope to determine how they may relate to either a past discharge out of Argyre basin along the Uzboi-Ladon-Morava mesoscale outflow system, a possible lake in Ladon basin, deposition in Holden crater and(or) Ladon and Uzboi Valles to the south, or alluvial-fan-forming events recognized in the region.
Mapping quads -15032 and -20032
Status of Map

- The primary map base is the controlled daytime THEMIS IR mosaic, supplemented with CTX images where available.
- Mapping is being done at 1:200,000, with an expected map publication scale of 1:1,000,000.
- All geologic units have been defined and mapped.
- All linear features have been defined and mapped.
- Crater size frequency distributions have been completed to determine ages.
- COMU and DOMU have been completed
Topographic Data Sets

MOLA over THEMIS dayIR
HRSC DTM (200 m contours)

HRSC DTM 9X VE
Measuring craters for determining approximate ages
Crater Units

All clearly delineated ejecta blankets and crater rims for craters \(~5\) km in diameter and greater have been mapped.

The Late to Early Hesperian craters (C1) are moderately degraded craters with relatively continuous ejecta.

Late Hesperian to Late Amazonian craters (C2) have well-preserved ejecta, with little rim modification and/or infilling.
Mountainous Unit (Middle Noachian) Nm
(Irwin and Grant, 2013)
The Mountainous Unit contains remnant high-standing bedrock promontories from the Ladon and Holden basin ring structures that date to the Early to mid-Noachian.
Terra Unit (Early Hesperian to Late Noachian) HNt
[Irwin and Grant, 2013]

The Terra Unit is a widespread, smooth to rolling, cratered and variably dissected surface between degraded impact craters. It covers much of the terrain outside of Ladon basin in our mapping region.
Channel Units (Late Noachian to early Hesperian) HNch1 and HNch2 [Irwin and Grant, 2013]

The formation of Ladon Valles produced both an early flooded surface (unit HNch1) and a later flow that coalesced into a single channel (HNch2)
Basin fill (Amazonian to Late Noachian)
Ladon basin accumulated fill materials that could be older sediments from Ladon Valles, later fluvial deposits from centripetally draining valleys, and possibly volcanic flows.
Alluvial Fans Unit (AHf)
Late Hesperian to Early Amazonian Fan unit occurs on the interior slopes of craters with preserved paleo-channel networks [Wilson et al., 2015].
Volcanic Unit (Av) Late Hesperian to Early Amazonian
Consists of 2 volcanic cones and associated lava flows
Laodn Valles and Ladon basin light-toned layered unit (Early to Late Hesperian) Hl1
A light-toned unit consists of medium- to light-toned, phyllosilicate-bearing beds with meter to submeter thickness and lateral continuity to kilometers.
Ladon uplands light-toned layered unit (Late Hesperian) HI2

A light-toned unit consisting of medium- to light-toned, phyllosilicate-bearing beds with meter to submeter thickness. Found in Holden secondaries and valleys along western uplands.
Layered deposits within upland valleys
Deposits contain mixtures of Fe/Mg-smectites

- HiRISE DTM at 5X vertical exaggeration merged with CRISM spectral parameters in color.
- The red spectrum exhibits a weak absorption at 2.29 µm that is consistent with nontronite while the blue spectrum has an absorption at 2.31 µm that matches saponite.
- Yellow arrows identify a 15-m high inverted channel within a 120 m deep valley at Arda Valles.
Light-toned Altered Unit (Ha) (Early to Late Hesperian)
Light-toned, possibly layered, deposits along crater floors. Possible or no obvious valley that flows into the crater. We are uncertain if the unit consists of detrital sediments like Hl$_2$ or represents in situ alteration of pre-existing crater floor deposits.
Geologic History

- Formation of Ladon and Holden impact basins in the middle Noachian, producing mountainous unit Nm.
- Landscape degradation and infilling during the Middle/Late Noachian with the terra unit HNt.
- Formation of Ladon Valles in the Late Noachian to Early Hesperian by catastrophic flooding to produce channel units HNch\(_1\) and HNch\(_2\).
- In the Late Noachian through the Early Hesperian, Ladon basin floor accumulated sediments that resulted in units HNb1, HNb2.
- Deposition of light-toned layered sediments (Hl1) during the Early to Late Hesperian within Ladon Valles and Ladon basin.
- Light-toned layered detrital sediments were deposited in blocked valleys and craters along the western uplands (Hl2) during the Late Hesperian.
- Alteration on some crater floors to form light-toned materials (Ha) during the Early to Late Hesperian.
- Eruption of volcanic flows and formation of volcanic cones in the Late Hesperian to Early Amazonian.
- Impact craters throughout the Noachian to Amazonian (H\(_C1\), AH\(_C2\)).
- Dark-toned mantle formed in the Late Hesperian to Amazonian and was eroded within the basin (AH\(_b3\))
### DESCRIPTION OF MAP UNITS

<table>
<thead>
<tr>
<th>Unit Label</th>
<th>Unit Name</th>
<th>Unit Definition</th>
<th>Additional characteristics</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHe</td>
<td>Crater 2 unit (Late Amazonian to Late Hesperian)</td>
<td>Floor, rim, and continuous ejecta of morphologically fresh impact craters little modified by rim erosion and (or) infilling. Unmapped crater at -18.5°S, 330.7°E.</td>
<td>Impact material, fractured rim and continuous ejecta of Hesperian and Amazonian impact craters.</td>
<td>Moderately degraded crater rim and impact ejecta from Hesperian unainted craters.</td>
</tr>
<tr>
<td>HPe</td>
<td>Crater 1 unit (Late to Early Hesperian)</td>
<td>Floor, rim, and partial ejecta of impact craters moderately modified by rim erosion and (or) infilling. Unmapped crater at -18.5°S, 330.7°E.</td>
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<tr>
<td>AHe</td>
<td>Volcanic unit (Amazonian)</td>
<td>Smooth unit that emanates from cone-shaped outcrops characteristic of volcanic edifices that produced lava flows. Ladin basin southern edge (-19°6'S, 328°6'E).</td>
<td>Overlapping, circular depressions common at centers of cone-shaped outcrops (V2704019).</td>
<td>Constructed vents deposited by effusively erupted fluidized sediment (mul breccia) and (or) lava during the Early Hesperian. Primary sources for the Nephele flow unit (HnH). Morphotopic variation due to different eruptive styles, volatile content, and (or) tapping depth.</td>
</tr>
<tr>
<td>AHe</td>
<td>Alluvial fan unit (Early Amazonian to Late Hesperian)</td>
<td>Sloping or cone-shaped deposits. Distributary palaeochannel networks preserved in negative or (more commonly) positive relief.</td>
<td>Cored deposits derived from deeply dissected impact crater walls coalesced into fans in unnamed craters at -15°2'S, 332°8'E. Bright in THEMIS nighttime IR.</td>
<td>Alluvial deposits composed primarily of gravel and fines, emplaced by fluvial sediment transport with no evident contribution from debris flows. Low abundance of bounders at HRSC scale.</td>
</tr>
<tr>
<td>AHe</td>
<td>Ladon basin fill unit 3 (Late Hesperian to Amazonian)</td>
<td>Smooth, dark-toned plains that are being eroded into mesas with steep edges where they have been mapped. Smaller lower relief outliers below mapping resolution are common across the Ladon basin floor.</td>
<td>Generally high thermal inertia, but variable due to different thickness of overlying AH03 unit.</td>
<td>Moderately to strongly indurated alluvial, volcanic, or aeolian fill materials. Origins include resistant indurated sediments and (or) thin lava flows during the Early Hesperian to Late Noachian. Possibly HnH that has been eroded down and now has a smooth this horned mantle. Alternately, a deeper outcrop within Ladon basin that has a lower thermal inertia.</td>
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<tr>
<td>HnH</td>
<td>Ladon basin fill unit 2 (Early Hesperian to Late Noachian)</td>
<td>Relatively smooth, low relief plains confined to Ladon basin floor. Unit appears ejected by the wind to create lineations and knobs.</td>
<td>Some deposits occur within Holder crater secondaries. Inverted channels and topography observed within some deposits.</td>
<td>Alluvial and eolian sediments containing phyllosilicates that were deposited during the Late Hesperian by water from valleys along the western Ladon basin uplands.</td>
</tr>
<tr>
<td>HnH</td>
<td>Ladon basin fill unit 1 (Early Hesperian to Late Noachian)</td>
<td>Relatively smooth, low relief plains that is only visible where overlying HnH1 has been eroded. Knobs and lineations seen in HnH are not observed, given the unit a smoother appearance than HnH1.</td>
<td>In Ladon Valles, unit overlies channel materials (HnH1c and HnH2d). Holder secondaries disrupt unit at the mouth of Ladon Valles.</td>
<td>Fine-grained phyllosilicate-bearing, lacustrine and (or) distal alluvial deposits from the Hesperian overlain by course-grained alluvial sediments and overlain sediments sand sheets of likely basaltic meteorite.</td>
</tr>
<tr>
<td>Hs</td>
<td>Light-toned altered unit (Early to Late Hesperian)</td>
<td>Mediums to light-toned deposit with few or no beds located within channel or riverine configuration.</td>
<td>CRISM data not yet available to determine if deposits are hydrated.</td>
<td>Could be thinner sedimentary deposits like H2L or material altered along crater floors by water ponding inside crater.</td>
</tr>
<tr>
<td>HsHe</td>
<td>Crater fill unit (Early Hesperian to Late Noachian)</td>
<td>Relatively smooth, low relief plains confined to impact crater floors.</td>
<td>AHF overlaid.</td>
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