Deciphering the Temporal and Spatial Relationships of Stratigraphic Units within the Claritas Region; Mars through a new Preliminary 1:1,000,000-scale Geological Map

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CALTECH STUDENT-FACULTY PROGRAMS



place name labels, C.M. Rodrigue (2009)

http://web.csulb.edu/~rodrigue/geog441541/mercatorMOLA.jpg



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Why is it Important?



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Units of the Claritas Rise



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Four Highland Units

Late Noachian Highland (INh) Middle Noachian Highland (mNh) Early Noachian Highland (eNh) Noachian Highland Edifice (Nhe)

Four Volcanic Units Amazonian-Hesperian Volcanic (AHv) Late Hesperian Volcanic (IHv) Early Hesperian Volcanic (eHv Noachian Volcanic Edifice (Nve)

Two Impact Units Noachian Impact (Ni) Amazonian-Hesperian Impact (AHi)

One Flow Unit Impact Flow (if)

Highland Units of the Claritas Rise



Late Noachian Highland (INh), CTX, ~25km across

- Dissected by late stage graben.
 Lightly cratered.
- Occurs in depressions and embays mNh, eNh, Nve, and Nhe.



Middle Noachian Highland (mNh), CTX, ~25km across

Heavily deformed by regional graben. Impact events range from sub kilometer to tens of kilometers in diameter. Superimposed by INh and embays eNh, and Nve,

• Highland Units of the Claritas Rise (cont.)



Early Noachian Highland (eNh), CTX, ~25km across

- Roughly textured with stark, high relief
- Heavily deformed by graben and general erosion



Noachian Highland Edifice (Nhe), CTX, ~25km across Relatively smooth outcrops, irregularly interspersed peaks

• Volcanic Units of the Claritas Rise (cont.)



Amazonian-Hesperian Volcanic (AHv), CTX, ~5 km across

- "AHv" according to Tanaka (2014)
- Lobate flows comprising most of the **Tharsis** volcanic flanks
- Overlays



Late Hesperian Volcanic (IHv), CTX, ~5 km across,

"IHv" according to Tanaka (2014) Lobate flows comprising much of **Syria Planum**

Embays mNh and eNh, and Nhe

• Volcanic Units of the Claritas Rise



Early Hesperian Volcanic (eHv), CTX, ~25km across

- Smooth, planar lobate flows
- Occurs b/w younger volcanic units in depressions, embayments



Noachian Volcanic Edifice (Nve), CTX, ~60km across

- Nve according to Tanaka (2014) Protrudes from contact of mNh and IHv
- Apparent effusion from central calderae

Impact Units of the Claritas Rise



Amazonian-Hesperian Impact (AHi), CTX,

- ~32km Diameter
 - Impacts range from sub kilometer to tens of kilometers in diameter
 - Well formed aprons
 - Not deformed by faulting

Noachian Impact (Ni), CTX, ~32km across

- Kilometers to tens of kilometers in diameter
- Little to no remaining apron
- Heavily deformed by faulting

• Flow Unit of the Claritas Rise

Rampart-like effusion, but can occur inside **and/or** outside crater rim



• Graben of the Claritas Rise



South Claritas Fossae, HRSC, ~140km across

• Graben of the Claritas Rise



South Claritas Fossae, HRSC, ~140km across

• Graben of the Claritas Rise



South Claritas Fossae, HRSC, ~140km across

- Stress/strain analysis on elongate)d craters
- Average orientation: N3.97°E (West) and N3.95°W (East)
- <u>Average amount of deformation</u>: 2.7km (East) 3km (West)

Listric Detachment Faulting

- South Claritas, HRSC, ~60km of faulting (at right)
- Up to 1000ft of vertical offset
- Strikes NW/SE for ~550km



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Collapsed Volcanic Tubes



THEMIS, ~60 km across

- Circular depressions, sometimes in chains
 - (easily confused for craters!)
- Very high-relief escarpments

• "Sigmoid Region" of the north Claritas Rise



- THEMIS, ~230km across
- Apparent zone of convergence for Claritas graben
- Older, more contorted extension?

Regional Compression?



- Antiform proximal to impact event ~20km long
- Little obvious evidence of compression and strikeslip...?

• Tectonic History - Faulting







Early Noachian Highlands, 1

250 200



Early Noachian Highlands, 2



Early Noachian Highlands, 3







Middle Noachian Highlands, 1



Middle Noachian Highlands, 2



Middle Noachian Highlands, 3





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Middle Noachian Highlands, 4









Middle Noachian Highlands, 5

Syria Planum Flows, 1



Syria Planum Flows, 2







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Syria Planum Flows, 3





Syria Planum Flows, 4





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Syria Planum Flows, 5





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Early Noachian Highland Events (early Stage 1)

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Two!graben!sets, !respectively!oriented!at!! approximately!50° !ENE!(blue)!and!30° ! NNW!(orange). !The!orange&rending!swarm!is!! older!the!blue!swarm.!(Rose!diagram:!eNh_2).! !

One lgraben lset loriented lat lapproximately 120°! ENE. !(Rose ldiagram: leNh_1). !

Middle Noachian Highland Events (late Stage 1)



The "sigmoid region", graben apparently emanating out of a linear locality near the centersouth of the figure. The blue and gold lines correspond in orientation to two later graben swarms that appear to cross-cut the feature post tectonically.

(Rose diagram: mNh_5)

The orientations of the three oldest graben sets visible on mNh (corresponding to 4-6 on the correlation chart). From oldest to youngest – blue, orange, gold. These swarms permeate the majority of the southern highlands. (Rose diagram: mNh_2).

Early Hesperian Arsia Mons Events (Stage 2)



Two graben swarms cross-cut the oldest flow from Arsia Mons documented in the mapping area. In the red box indicated, the graben swarm that strikes further to the northeast appears to be younger.

Mid-Hesperian Syria Planum Events (late Stage 3)



The two major graben trends in Syria Planum are represented in orientation by the orange and gold lines. (The graben swarm indicated in orange becomes buried under the teal Syria Planum lava flow, indicating that it is older than the cross-cutting gold graben swarm.) Claritas Rupes, a large listric detachment fault, serves as the eastern boundary of the Thaumasia graben (which is bounded on its western end by the middle Noachian highland (mNh) in purple. The Thaumasia graben extends nearly to the southern boundary of the mapping area. *Note:* The white graben belongs to a much later event.

Hesperian-Amazonian Syria Planum Events (Stage 4)



This figure comprises approximately the northernmost quarter of the mapping area, showcasing five of the six mapped Syria Planum lava flows. The middle Noachian highlands (mNh, after Tanaka et al [2005]) is depicted in pink in the far southwestern corner of the map, with the southernmost collapse pits of Noctis Labyrinthus in the far northeastern corner. Syria Mons lies at the white star in the mapping area, with the graben event forming concentrically about the peak across (from left to right) the three youngest flow units associated with Syria volcanism.

Hesperian-Amazonian Arsia Mons Events (Stage 4?)



The stepovers are highlighted as blue lines in the western part of this figure. The toe of the next-youngest Arsia Mons lava flow is depicted in peach in the center-north of the image, with the early Noachian highlands in purple at left.

Work to Go

Science

Future analyses: IDing cross-cutting relationships to graben swarms to unit emplacement.

Crater Counts

The relative ages of each unit in this particular mapping area must be constrained.

Publication

Map units need to be correlated, the map as a whole is to be standardized to USGS practices.

Stress/strain analysis of each extension event. Submission to USGS for iterative review.