Fluvial activity in the Northeast Syrtis Major region and its link to glacial processes in the Hesperian

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Introduction

The geology of the northeast edge of the Syrtis Major volcanic complex records a diverse history of early Mars. This region contains a stratigraphic record that spans from the period of the Noachian to the Amazonian [1]. We identify a channel and basin system (Fig. 2) that straddles this divide and attempt to answer the following:

1. What are the likelyest hydrological sources for the upland source channels? (Fig. 3)
2. What enabled basin drainage via topographically higher outlet channels, despite the existence of a topographically lower potential outlet to the southeast? (Fig. 4)
3. What preserved the basin as an isolated depression at the terminus of a large volcanic field? (Fig. 4)
4. To what extent do the responses to the preceding questions suggest glacial activity at this geologic transition zone? (Fig. 5)

Methods

Surface morphology and topography was assessed using cameras, altimeters, and spectrometers known as CTX, HRIRSE, MOLA, and HRSC [2,3,4,5]. Local topography determined using HRIRSE derived digital elevation models provided by the USGS [6]. All imaging data are maintained in an ArcMap GIS database.

Mineral composition was determined with reflectance spectra using visible and near-infrared data from CRISM after being calibrated using the volcano-scan technique [7].

Results and Discussion

- Flow channels follow topography (Fig. 3A) until reaching the mesa (Fig. 3B)
- Once on the mesa, they diverge into two channels
- One goes east into the basin over sulfates with a boxwork texture (Fig. 3C)
- The other channel travels off the mesa the south causing erosion (Fig. 3D)
- The edges of the volcanic flows are highly irregular with steep cliffs (Fig. 3E)

- This area (Fig. 4A) contains two distinct volcanic units
  - The Hesperian Syrtis Major Volcanic unit that borders the basin (Fig. 4B)
  - One of Amazonian age within the basin (Fig. 4C)
- Age difference suggests protection of the basin through some mechanism

Conclusions

- The diffuse source morphology suggests a precipitation origin of the system's water (Fig. 3A)
- The outlet channel is consistent with current topography and would require significant erosion on the southeast edge of the basin or a temporary paleo ice dam (Fig. 2, 5B)
- A large ice sheet would halt the flow of the lava in order to preserve the basin and prevent infilling of volcanics (Fig. 5A)

Collectively, these observations suggest late-stage, glaiofluvial processes in the Northeast Syrtis region with a basin preserving ice sheet and an episodic ice dam over 1 km thick (Fig. 5).

Regional glaciation has been suggested in this location before [12], however, we are able to place more specific constraints on the western portion of the ice sheet based on these morphological observations (Fig. 5A).

In addition to areal extent, we are able to infer the periodic existence of this glaciation (Fig. 5B) based the multiple outlet channels observed (Fig. 2).

Acknowledgements and References

This work has benefited from reviews and discussions with Tim Goudge, Steven Ruff, Jim Head, and Bethany Ehlmann. All data and observations used in this study are publicly available from the NASA PDS. Thank you to LASA and NASA for providing funding via the ISSR and both MGO and RAP via Suniti Karunatillake. Lastly, thanks to the Planetary Science Laboratory of LSU for the countless laughs, thoughtful discussions, and coffee runs.


Figure 1. The regional context of Northeast Syrtis, Mars MOLA globe shows the location of the underlying image (black box). The region is located at the Northern edge of the early Hesperian, Syrtis Major volcanic flows. The ~3050 m contour line cuts through the eastern section of our focus area and marks a dichotomy boundary around Isidis and the Northern Lowlands.

Figure 2. Map of channel system on the edge of northeast Syrtis. Red contour ~2450 m indicates the highest level fully encroached by the current basin topography, yet hydrologically accessible to the SE potential outlet channel. Red contour ~2350 indicates minimum lake level required to activate the eastern outlet channel. (Background: CTX mosaic with colored HRSC DEM overlay)

Figure 3. Upland source channel terrain with tightly eroded braided channels on volcanic lava fields. (Background CTX mosaic with colored HRSC DEM overlay, insets are HRIRSE images)

Figure 4. Crater counting for two distinct volcanic units within our study area and corresponding plots created with Craterstats 2.0. (Background CTX mosaic with colored HRSC DEM overlay)

Figure 5. Minimum required extent of ice cover for the morphological observations. (Background CTX mosaic with colored HRSC DEM overlay)

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