FLUVIAL ACTIVITY IN NORTHEAST SYRTIS MAJOR AND ITS RELATIONSHIP TO GLACIAL PROCESSES IN THE HESPERIAN.

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Introduction: This project develops evidence for large scale ice sheets within the Hesperian by utilizing morphological features of a basin and channel system located in Northeast Syrtis Major. We observe and analyze a fluvial channel and basin system that straddles the Hesperian volcanics and Noachian plains. Our analysis is consistent only in the presence of an episodic glacial history that spans the early Hesperian and would cover likely extend to the dichotomy boundary and Isidis Basin. The observations in Northeast Syrtis provide key stratigraphic constraints on the ancient climate of Mars that can be tested with the Mars2020 mission to the adjacent Jezero Crater delta.

The fluvial system that we characterize consists of four discernable features: upland source channels, basin, outlet channels, and terminal fan (**Figure 1**). We look to answer one encompassing question: to what extent does the local geology suggest glacial activity at this geologic transition zone?

Observations and Implications: The upland channels have no clear origin point. While a fluvial origin has been favored, we have considered alternative mechanisms, including volcanic channels. However, the lack of a spatially localized source, the meandering of the channels, and the erosion at the edge of the plateau suggest a distributed fluvial erosion rather than a lava channel formation. With a fluvial erosion mechanism, the lack of a localized origin can indicate a distributed source. Precipitation in the form of snow or ice, with subsequent basal melting would leave no erosional marks until the runoff concentrated to the point of carving the observed channels.

The basin had to survive regional volcanism, erosion of the surrounding terrains, and potential lacustrine fill to remain a topographic low. The 1100 km to the direct south of this small basin has been filled in by Syrtis volcanics, so how did this depression persist? The volcanic flows range between 0.5 and 1.0 km higher than the basin's floor with a 12° average slope on the flow edge. The relatively flat nature of the rest of the Syrtis flows suggests low viscosity lavas that should have overflowed and filled the basin if they had encountered the modern landscape. We find the lava flows that were possibly blocked to be 1.3 ± .2 Ga older than the ones that eventually infilled the basin (**Figure 2)** based on crater counted ages [2]. This suggests an obstruction, now-absent, that halted the volcanic flows near the irregular surface before disappearing and allowing subsequent volcanic flows to infill the basin.

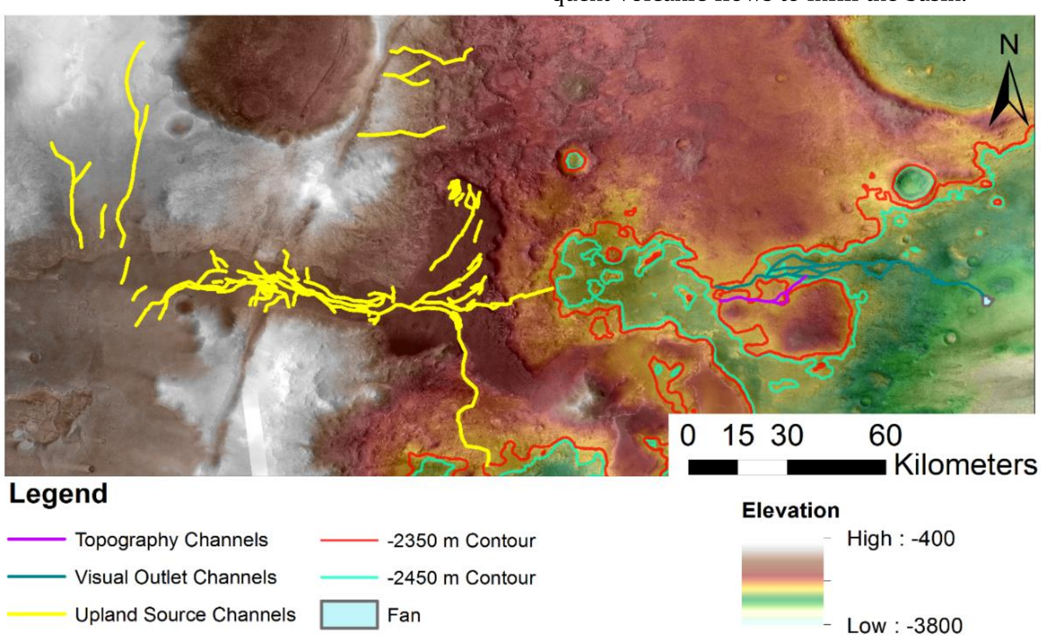

Figure 1. *Map of channel system on the edge of northeast Syrtis. Teal contour (-2450 m) indicates the highest level fully enclosed by the current basin topography, yet hydrologically accessible to the SE potential outlet channel. Red contour (-2350 m) indicates minimum lake level required to activate the eastern outlet.*

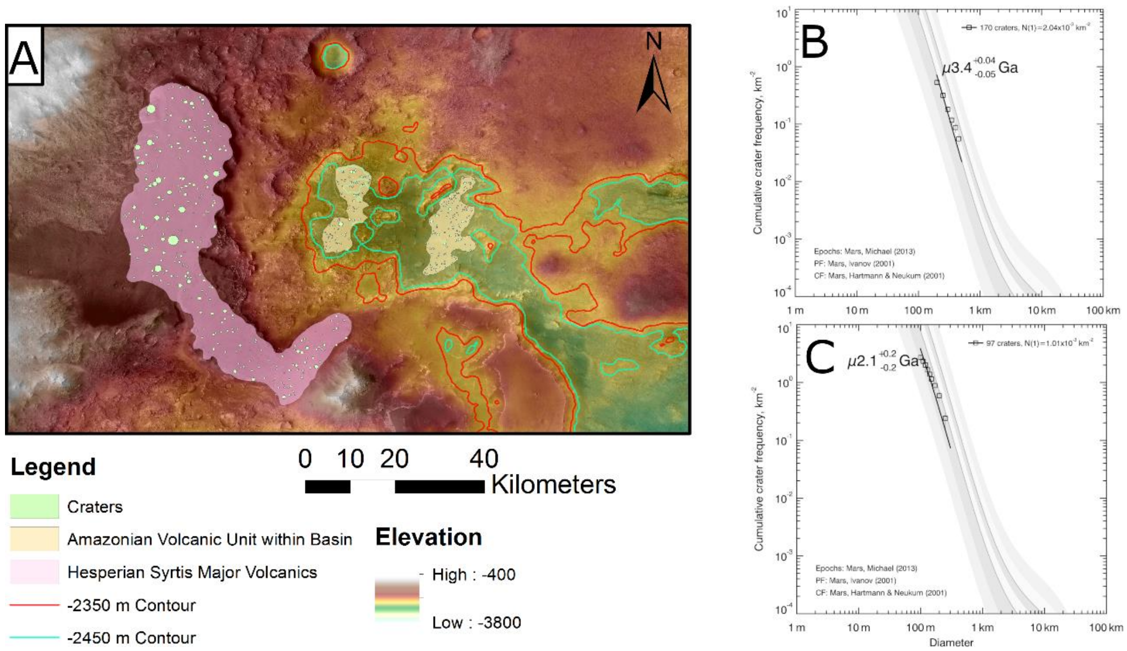

Figure 2. *A) CTX mosaic shows the three regions with crater-based relative geochronology given their position compared to the basin. Two areas within the basin (yellow) were dated to the Amazonian while the larger unit to the west (pink) is dated to the Hesperian. B) Age determination for the delineated pink region C) Age determination for the western yellow unit.*

The basin drained via topographically higher outlet channels, despite the existence of a 100 m topographically lower potential outlet to the southeast. The current passage topography may have existed during the time of fluvial activity, albeit during a time of mid-latitude ice deposits. The typical ~40° obliquity occurring as recently as 5 Ma ago suggests the likelihood of such events [1]. A 200 m tall ice dam could block that passage and force discharge through the eastern, higher elevation, passage. The presence of regional ice units would then require an atmospheric source for the fluvial activity. Eventual sublimation of the dam after fluvial activity could remove evidence of the passage blockage without leaving traces of material. The observed lack of erosional features in the southeast passage would best be explained by the ice dam hypothesis (**Figure 3**).

Conclusions: This system represents a second distinct episode of fluvial activity in the region, with the first defined by the Jezero open basin crater lake at 3.74 Ga [3]. Large scale glaciation has been suggested in the Northeast Syrtis region before [4,5,6], but our work reveals the possibility and extent of local ice deposits complementing numerical models. Our observations establish that this second episode occurred after the early Hesperian emplacement of Syrtis Major volcanics. Collectively, these observations contribute to a more detailed understanding of the late-stage glaciofluvial processes in the northeast Syrtis region, at the transition from the Noachian marked by possibly moderate pH aqueous conditions to the Hesperian marked by acidic and volcanic conditions.

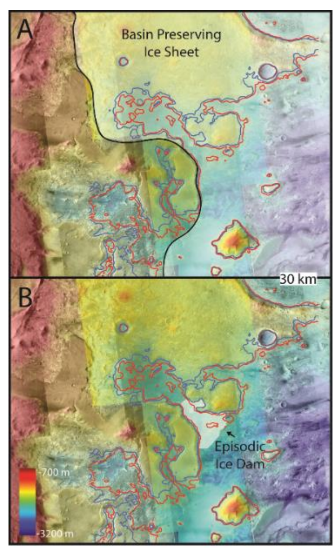

Figure 3. *Suggested ice positions. A) Black line shows the potential extent of ice cover during the early Hesperian emplacement of the Syrtis lava. B) The potential ice dam illustrated here would enable discharge through the eastern outlet channels. Its episodic existence would explain the presence of multiple channels.*

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