WATER-LIMITED PROVENANCE OF THE VASTITAS BOREALIS FORMATION WITHIN ISIDIS BASIN, MARS. A. Bates[1], S. Karunatillake[1], J. M. Lorenzo[1], K. M. Konsoer[2], E. B. Hughes[3]; [1]Department of Geology & Geophysics Louisiana State University (abate15@lsu.edu); [2]Dept of Geography, Louisiana State University, [3]Georgia Tech University

Introduction: The presence of a seemingly homogeneous depositional layer within the northern lowlands of Mars, called the Vastitas Borealis formation (VBF), has often been cited as evidence of a once present ocean within the lowlands (1–5). However, inferences on the timing and mechanism(s) of deposition and the geologic homogeneity of the VBF have changed over recent years (6), especially within Isidis basin (7). The basin floor within Isidis is mapped and classified as part of the VBF (8) but analysis of small-scale morphology within the basin reveals a distinctive landscape characterized by arcuate ridges with shared orientations and fluvial channels along the basin rim (7, 9) features which are distinct from those found further into the lowlands (6). The ridges in Isidis have been interpreted to have a glacial origin, but the fluvial channels which extend outward from the basin into the highlands and lowlands may not be coeval with these glacial features. It is possible that these fluvial features are representative of a different climate and as such their morphology and relative age could serve to constrain the possibility of a large standing water body within Isidis and the northern lowlands. Furthermore, geochemical evidence of aqueous alteration within Isidis has thus far been limited to analysis of CRISM data, which doesn't provide the regional context that would be associated with a large standing water body.

In this study we aim to investigate the likelihood of liquid water ponding within Isidis basin through analysis of regional geochemistry and fluvial morphology. The shared presence of the VBF between Utopia basin and Isidis could indicate a shared formation mechanism, i.e. that the VBF represents a sublimation lag deposit from a once frozen body of water (6). As such, the chemistry of Isidis should show signs of significant aqueous alteration and the fluvial should exhibit morphologies consistent with large drainage areas to supply an appropriate amount of water to support ponding within Isidis. Furthermore, the relative age of these channels can inform us of the climate in which they formed, such as the hypothesized transition to warm and wet in the Hesperian (4).

Methods: This study aims to characterize the fluvial morphology in and around Isidis basin with specific focus on channel planform, which would be primarily influenced by drainage area in the absence of vegetation (10). The relative size and source (alluvial, groundwater, etc.) of the drainage areas around Isidis can be used as proxies for past climate. While HiRISE images offer unparalleled resolution, their local scope makes regional interpretations difficult. In order to circumvent this issue, we use the Context Camera (CTX) Mosaic, built by Murray Lab at CalTech. CTX images have a resolution of 5m/pixel and the mosaic offers near global coverage. With this resource, the user is able to quickly vary the field of view in order to determine areas of connected drainage at the regional to local scale. We map these channels with the default drawing tool within ArcGIS. The blue lines in all of the figures in this study are a result of the user's interpretation of the channel path, following what is preserved on the landscape at CTX image resolution.

We also examine the regional chemistry around and within Isidis using Gamma Ray Spectrometer (GRS) derived data. In order to enhance the rigor of our geochemical analyses, we also employ 2 methods of Mg estimation based on measured cation abundances from the Pathfinder landing site (11) and from a regression-based method derived from martian meteorite compositions (12). Modeling Mg abundance allows for more robust geochemical analyses such as chemical index of alteration (CIA) calculations and plots in ternary space, both of which can be effective in identifying areas of significant aqueous alteration (13, 14).

Results: The results of our fluvial mapping are shown in Figures 1 and 2. Figure 1 shows a fluvial system near the SW rim of Isidis. The morphology of this system seems to be dominated by drainage of proximal areas of higher elevation. The overall length of the single, main channel is roughly 200km.

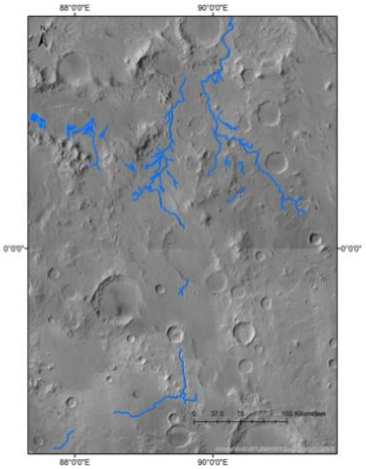

Figure 1: Fluvial systems along the SW rim of Isidis. The systems in this image appear to drain adjacent areas of higher topography, as there are clear tributaries which feed into a single, main channel. The convergence of tributaries off areas of high elevation is clear in most cases,

but the subsequent main channel that would form is difficult to identify in some cases.

Figure 2 shows a fluvial system to the NW of Isidis, whose morphology is much different from the system shown in Fig. 1. The system in Fig. 2 is characterized by chaotic changes in morphology, going from single channel to braided several times within the extent of the figure. The morphological differences between these 2 systems are likely driven by differences in flow regime, as terrestrial braided rivers are commonly associated with areas of variable discharge.

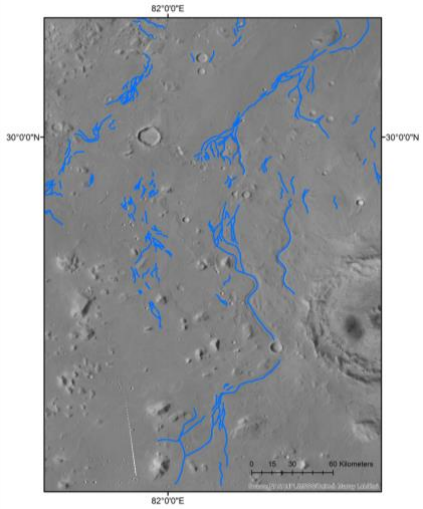

Figure 2: The braided or anabranching morphology of a fluvial system near Nili Fossae, to the NW of Isidis. This system appears to avoid small craters and drain off the larger crater in the bottom right of the figure. This would suggest these fluvial systems are likely the youngest feature in the image, which would mean they formed after the deposition of the VBF.

Figure 3 shows CIA values calculated from our two Mg estimation methods for Isidis based on prior geochemical mapping (15). Our two methods of estimation effectively bound the possible range of CIA values for Isidis.

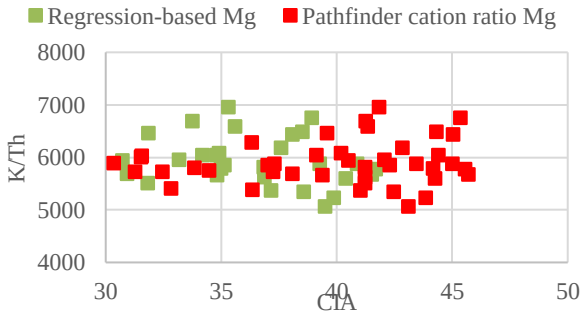

Figure 3: CIA values for 2 Mg estimation techniques versus K/Th ratio, after (13)*. While CIA values vary significantly, generally the pathfinder cation method results in higher CIA values relative to the regression method. The overall trend is suggestive of limited to no aqueous alteration.*

From our geochemical observations, it is difficult to attribute a governing deposition process (i.e., fluvial versus air-fall) to the VBF within Isidis. However, the regional geochemistry is generally supportive of a scenario with limited aqueous alteration, since our CIA values are below the threshold of 50 indicative of considerable aqueous alteration.

Discussion: We show the results of our mapping of prominent fluvial channels around Isidis. The morphology of these systems is highly variable, suggesting either (1) local, seasonal variations in discharge, which could be attributed to glacial meltwaters or liquid precipitation, around Isidis or (2) that these systems weren't coeval, and that the differences in morphology are a result of the changing martian climate from the Noachian to the Hesperian.

The geochemical trends suggest at most limited aqueous alteration at regional scales. Since GRS measures only the upper ~50cm of regolith, the observed chemistry is mostly reflective of the most recent resurfacing layer, in this case the VBF. The lack of depositional features (i.e., deltas) associated with the fluvial systems identified here may suggest that an air-fall event which post-dated some of the fluvial activity dominates the VBF within Isidis.

The fluvial features that exist outside of the basin (Fig. 2) may have formed after the deposition of the VBF. Since the fluvial systems along the SW rim of Isidis are distinct in their morphology, their formation could be attributed to a climatic shift. Overall, it appears that the fluvial activity around Isidis could both pre- and post-date the deposition of the VBF within Isidis, but with distinct changes in the overall drainage regime. Channels that predate the VBF's deposition appear to have more consistent annual flow and drain larger areas whereas those that postdate exhibit features consistent with variable annual flow and smaller drainage area. In addition, regional geochemistry supports a non-aqueous mechanism for the deposition of the VBF.

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